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An Encyclopædia

OF

TECHNICAL EDUCATION.

VOLUME III.

CASSELL, PETTER, AND GALPIN,
LONDON, PARIS, AND NEW YORK.

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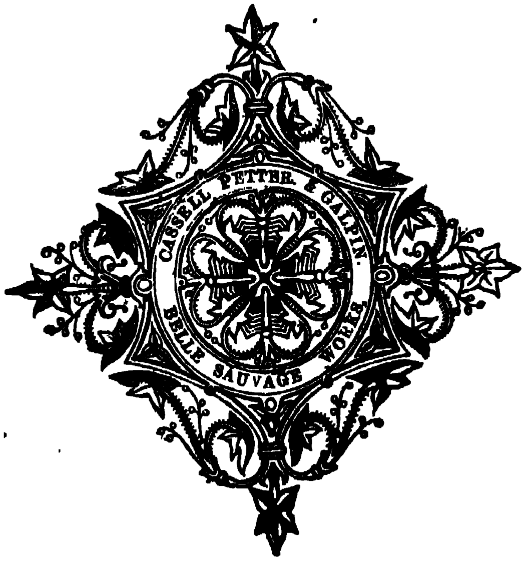

CASSELL, PETTER, & GALPIN.
BELLE SAUVAGE WORKS.

FIG. I.

The Solar Spectrum.

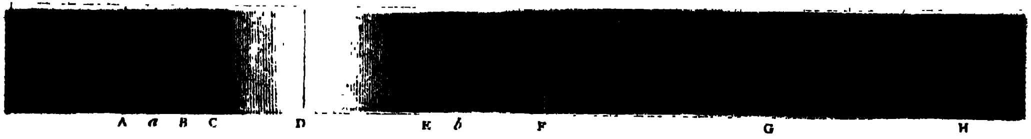
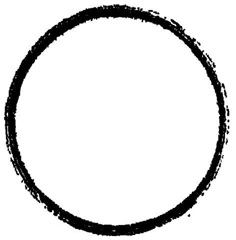
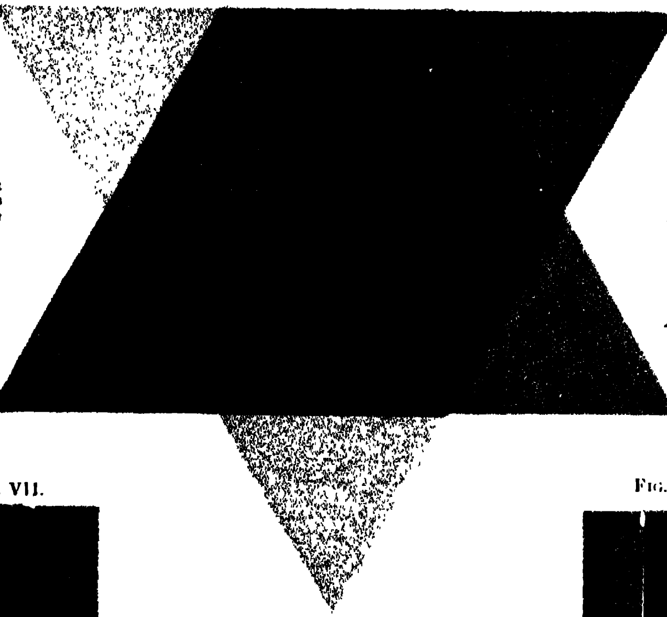


FIG. III



Subjective Colour.

FIG. II.

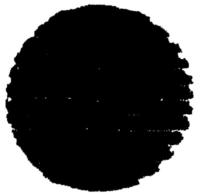


The Primary, Secondary, and Tertiary Colours.

FIG. IV

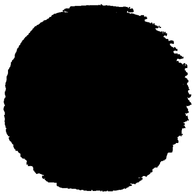
Colour as related to idea of Distance

FIG. V.



Effect on Colours of Apposition.

FIG. VI

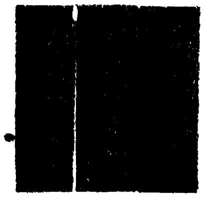


Mixture of Colours by Apposition.

FIG. VII.

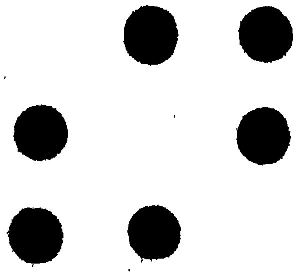
Indistinctness of Related Colours in contact.

FIG. VIII.



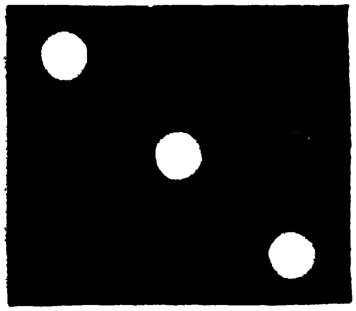
Effect of Black and White in separating Colours.

FIG. IX.



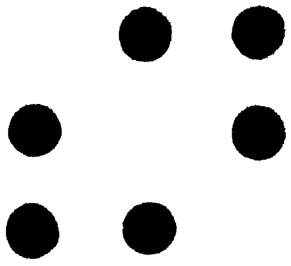
Effect of a Grey Ground on Colours.

FIG. X.



Effect of a Black Ground on Colours.

FIG. XI.



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THE

TECHNICAL EDUCATOR:

BEING THE TECHNICAL SERIES OF "CASSELL'S POPULAR EDUCATOR."

PHOTOGRAPHY.—I.

By J. C. Leake.

INTRODUCTION — PROCESSES — COLLODION PROCESS — PHOTOGRAPHIC CAMERA—PRACTICAL DETAILS OF WORKING—DARK CHAMBER.

The scientific art of photography, although of recent introduction, is of such great importance, and is so extensively employed in all branches of science, art, and manufactures, that a technical education can scarcely be considered as complete without a knowledge of it. The services rendered by so ready, simple, and accurate a method of recording facts, and of copying scenes from nature, drawings, or machinery, can scarcely be over-estimated; and the importance of the art may at once be judged from the fact that the governments of most countries consider it advisable to train a special body of men as photographers, that they may accompany any military expedition of importance, and by its means record any noteworthy events of the campaign. Under these circumstances we propose offering in these pages such instruction as may enable our readers to secure photographs of any scenes or objects of which copies may be required. But it is necessary to observe at the outset that our instructions should be followed implicitly in the first instance, and that no modifications of the process about to be described should be attempted until the operator is well grounded in what we may call the standard method of producing pictures. Of this there are many modifications; but these had better be left alone until complete success has been attained by means of the processes and formulæ which will hereafter be given, and which may be considered good and reliable in every particular. If this care be exercised, there need not be any difficulty in producing excellent pictures; but at the same time it must not be supposed that the art consists merely of pouring over glass plates certain chemical solutions; much tact and skill are necessary when really good work is required, and in many cases these qualifications will be taxed to the utmost extent. Above all things the utmost cleanliness is absolutely necessary; not the mere outward cleanliness of every-day work, but chemical purity of all the materials employed. For instance, a glass plate may be apparently clean and bright, while it is in reality so dirty as to be perfectly useless for photographic purposes. The merest speck of dust, or slightest trace of grease upon the glass, will produce spots and stains of such a character, as to render the photograph practically useless. Again, in the case of water employed in certain parts of the process, it is useless to direct the use of that which is merely clean: it must be pure, that is to say, it must be chemically clean. It cannot be too distinctly understood that in the various photographic processes chemical changes are involved which are of the most extreme delicacy, and that consequently the utmost care is requisite in order to exclude any extraneous substances which might interfere with the proper combinations and reactions of the chemicals employed. With these few preliminary remarks we may at once proceed to the practical details of our subject.

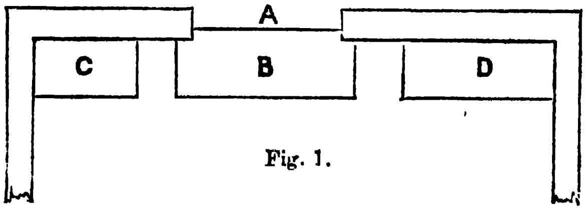

Fig. 1.

Although there are almost numberless processes and modifications of processes known to photographers, there is one which, for all practical purposes, is unrivalled as well for simplicity and certainty, as for beauty and delicacy of the resulting pictures. This is termed the "collodion process," and, as may be surmised, the impression is produced upon a film of collodion, which is supported by a plate of glass. This may be fairly called the standard process of photographic art, and at least nine-tenths of the photographs produced are made by means of it. Discovered and invented by Mr. F. Scott Archer in 1851, it still remains almost as its inventor left it in all important particulars, the nearest approach to a perfect photographic process to which we have yet attained.

The employment of a film of collodion to support certain salts of silver which are sensitive, and may be acted upon by light, may be considered almost as the starting point of practical photography, as so ready and certain a method had never before been introduced. Chemically the collodion film is inert, and plays no part in the actual production of a picture; it is merely the medium or vehicle which holds in solution the active chemical ingredients required. Collodion is a solution in alcohol and ether of a substance almost identical with gun-cotton, and which is termed pyroxyline; upon the evaporation of the solvents it leaves a thin transparent film of a tough character, closely resembling gold-beaters' skin. To a solution of the plain collodion are added certain salts called iodisers, such as the iodides of potassium, cadmium, or ammonium, and in the case of bromo-iodised collodion one or other of the bromides, after the addition of which the collodion is termed iodised. When a portion of this compound is poured over and spread upon a plate of glass, a certain quantity of the iodising salts are of course retained in the film, which is then totally insensitive to light. In order to render it capable of receiving an impression in the camera, the iodised film must be immersed in an aqueous solution of nitrate of silver, which combining with the iodides and bromides contained in the film, forms a layer of iodide or bromo-iodide of silver of the utmost delicacy and sensitiveness to the action of light. It is scarcely necessary to observe that the sensitising and all subsequent processes up to the time of fixing the image, must be performed in a room which is protected from the action of the actinic rays, as we shall presently explain. When the plate has thus been prepared, it is ready for exposure to the action of light in the camera.

The photographic camera is simply a box of wood or other opaque material, into one end of which is fitted a lens of a suitable character, and capable of projecting upon the sensitive surface an image of any object before which it is placed. At the reverse end of the box is fitted a screen of ground-glass, which is used for the purpose of adjusting both the position of the image upon the plate, and the distance of the lens from the sensitive surface, in order that it may be rendered perfectly sharp and distinct. A case or box having a sliding door is also made to fit into the same groove as the screen, and is intended to hold the sensitive plate during the adjustment of the camera. When this adjustment has been made, the box or slide containing the plate is inserted in place of the screen, and the shutter having been drawn up, the exposure of the plate to light is continued for the requisite time; after which it is removed to the operating-room for development.

Upon the removal of the plate from the camera, no trace of a picture is visible; but the latent image is rapidly developed upon the application to the sensitive surface of a solution of sulphate of iron or of pyrogallic acid. The picture thus produced, however, possesses this peculiarity, that all the lighter parts, such as the sky, are in the negative dark; while the darks are light or transparent: the whole of the gradations from extreme light to dark are thus reversed, the various shades being perfectly rendered by half tints. It is from this negative that copies with their lights and shades in their proper order are produced by the printing processes hereafter to be described. But as the sensitive film has only been darkened, and not actually removed by the action of light, it is necessary to remove the remaining sensitive salts from the picture before exposure to diffused light, in order to prevent a general darkening over the whole surface, which would, of course, obliterate all trace of a picture. This operation is called the "fixing process," and it is effected by flooding the plate with a solution either of hyposulphite of soda or of cyanide of potassium. Either of these salts will quickly remove the unaltered portions of the sensitive surface, and render the picture permanent and unaffected by the further action of light. Chemically the negative is now completed; but as the film forming the picture is one of exceeding delicacy, and is easily scratched or destroyed, it is necessary to coat it with a suitable varnish in order to protect it during the operation of printing.

With this brief outline of the collodion process, we may at once proceed to the practical details of working. For convenience of description we will suppose the photographer to commence his experiments at home, or at some place where the two great requisites, plenty of water and a convenient laboratory, are to be obtained. The laboratory should be a clean room fitted with shelves, several tables—if possible, a sink with a good supply of water laid on over it—and not more than one window of moderate dimensions. In order to render this room fit for photographic purposes, it will be necessary to exclude all light except that which passes through a yellow medium, which must be sufficiently dense to exclude all the actinic rays. A ready and cheap method of effecting this purpose is as follows:—Procure a light frame of wood, of such dimensions as may be required to completely cover the window opening. Upon this should be stretched at least four thicknesses of common yellow calico; the whole may then be hinged at the top or one of the sides of the window, as may be most convenient, taking the utmost care to exclude the smallest ray of white light, which would inevitably spoil the sensitive plate. It is well to have this screen easily removable, in order that an abundance of light may be readily admitted into the room while such portions of the process as may be performed in ordinary daylight, such as coating the plate and fixing after development, are in course of execution. The arrangement shown in Fig. 1 will give some idea as to the proper fitting of the developing-room or laboratory. In this A represents the window, immediately underneath which should be placed the sink B, or in default of this a table or shelf capable of supporting a suitable vessel for catching the waste developing solutions, and the water used for washing the plates. If possible the water should be laid on over this sink; the space marked C should be occupied by a strong table, to be used for the purpose of supporting the nitrate of silver bath required for the preparation of the sensitive plate. Over this a shelf or two should be erected, upon which the necessary chemicals may be kept so as to be within easy reach. Upon the opposite side of the sink, in the space marked D in the diagram, should be placed a similar table to that before mentioned, which should be used exclusively for the fixing process. This is important, as the smallest trace of the fixing agent usually employed, the hyposulphite of soda, would, if introduced at any of the earlier stages of the work, prove fatal to any hope of success. If photographic operations are to be carried on through the winter season, it will be necessary to have a stove in the room; and as a rule those in which gas is burned should be avoided, in consequence of the noxious fumes evolved. A close stove with an ordinary pipe chimney will answer every purpose, and is on the whole the most suitable for the situation. A cheap thermometer suspended in the room will be found to be most useful, as many failures may be traced to the fact of the temperature being too high or low. It is hardly necessary to observe that the operating chamber must be kept absolutely clean, and free from dust and dirt of every description. If the highest success be desired, the best of good order must be observed in all the arrangements of the laboratory, and a sufficient supply of soap and towels should be so placed as to allow of the hands of the operator being rinsed and dried at the conclusion of each part of the process. All bottles containing chemicals and solutions should be kept strictly in their places, and so conspicuously labelled as to be readily recognised even in the dull light which will, of course, prevail. Finally, upon no account must the slightest disorder be allowed in any particular, or the operator will speedily find himself involved in troubles and difficulties of every description.

The preparation of the dark chamber is a matter of the first importance, and consequently we have described it at considerable length; while although it must be done by each operator for himself, it cannot be correctly classed with actual photographic operations. For this reason we shall here conclude the present chapter, and in our next proceed to describe the various processes necessary in order to produce photographic pictures, as well as the apparatus required for the same purpose.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXII.—JOHN RENNIE, ENGINEER.

BY JAMES GRANT.

JOHN RENNIE, who may justly be considered as among the first, if not the first, of that great school of practical engineers which has been established in Great Britain, was the son of a respectable Scottish farmer, and was born at the homestead of Phantassie, in the parish of Prestonkirk in Haddingtonshire, on the 7th of June, 1761. In his fifth year he had the misfortune to lose his father, but his education was carried on at the parochial school by his mother and her family. Young Rennie's peculiar turn for mechanics and invention seems to have been fostered by his vicinity to the workshop of Andrew Meikle, an eminent millwright, the inventor or improver of the threshing-machine, who now lies in the humble churchyard of Prestonkirk, where his grave is marked by a handsome tombstone. In his frequent visits to Meikle's establishment, he was wont, boylike, to be "constantly occupied in using, and perhaps in abusing, the tools that fell in his way;" but as he advanced in years, he began to imitate at home, in the farmhouse of Phantassie, the models of machinery he had seen, and at the early age of ten had constructed those of a windmill, a steam-engine and pile-engine, in the last of which he is said to have exhibited much practical dexterity.

In his twelfth year, he was removed from the school of Prestonkirk, in consequence of some misunderstanding with the master, whom he had already begun to deem incapable of advancing him in his studies, and he entered the employment of Andrew Meikle, with whom he continued for two years; but finding his education deficient, in 1775 he went to Dunbar, where he studied mathematics under Mr. Gibson; and two years after, preferring mechanical employment, he returned once more to the workshop of Meikle. On his tutor Gibson being appointed rector of the Perth academy, he recommended young Rennie as his successor at Dunbar, where the future engineer taught the school for some weeks, but merely to oblige his friend, as he had no idea of teaching even mathematics as a profession.

Again he returned to Andrew Meikle, and employed all his leisure hours in modelling and drawing machinery, and so skilful did the lad become, that ere he had quite reached the age of eighteen, he had erected at least three corn-mills in his native parish; but the first work he undertook on his own account was the rebuilding of the flour-mills at Invergowrie, in Forfarshire. The energy with which he prosecuted his engineering labours in summer, afforded him sufficient funds to visit Edinburgh in the winter, and to attend the lectures of Dr. Black on practical chemistry, and those of Dr. Robison on natural philosophy, thus fitting himself for the profession to which he aspired, with honest and determined enthusiasm—that of civil engineer. By Professor Robison he was recommended to Messrs. Watt and Boulton at Soho, and on his way to that place he made a close and practical inspection of the Lancaster aqueduct, the Liverpool Docks, and the Bridgewater Canal; and after remaining some months at Soho, he travelled through the Yorkshire manufacturing districts, and finally settled in London in 1783.

At this time there occurred that which may be deemed an era in the history of the great manufacturing establishments of Britain—the erection of the Albion flour-mills in London.

Messrs. Watt and Boulton planned the scheme, but the construction of the two great steam-engines, and all the millwork and machinery connected therewith, were confided to John Rennie; and Watt has himself recorded, in a note to Robison's "Elements of Mechanical Philosophy," the valuable assistance which he derived from his young friend in those great works, which were eventually and wilfully destroyed by fire in 1791, when an ignorant mob, believing that monopoly was injurious to public good, thought to reduce the price of flour by an act of incendiarism.

"The Albion mills," says James Watt, "consisted of two engines, each of fifty horse-power, and twenty pairs of millstones, of which twelve or more pairs, with the requisite machinery for dressing the flour and other purposes, were generally kept at work. In place of wooden wheels, always subject to frequent derangement, wheels of cast iron with teeth truly formed and finished, and properly proportioned to the work, were here employed, and other machinery which used to be made of wood, was made of cast iron in improved forms; and I believe the work executed may be said to form the *commencement* of that system of millwork which has proved so useful to this country."

Mr. Samuel Wyatt designed and executed the buildings; but the superior mechanism of the Albion Mills brought Rennie prominently into the notice of the public, that he soon obtained extensive employment in the construction of sugar-mills for the West India planters: and as his circumstances were fast improving, in 1789 he married.

He constructed the machinery of the powder-mill at Tunbridge, of the flax-mill at Wandsworth, of the rolling and triturating mills of the Mint in London; of Messrs. Whitbread's brewery, and many other breweries and distilleries; and the year 1794 saw him regarded as the head of the profession of civil engineers in Great Britain, and in connection with every public work of importance in the United Kingdom. In all the millwork erected by Rennie, there was one remarkable improvement that was strictly his own idea. "It was formerly usual to place the vertical axis of the running millstone in a bush, placed in the middle of the horizontal bridge-tier, which was supported only at its two extremities. The effect of this was that the bridge-tiers yielded to the variations of pressure arising from the greater or less quantity of grain which was to be admitted between the millstones, which was conceived to be a useful effect: but Rennie made the bridge-tier perfectly immovable, and thus freed the machinery from that irregular play which sooner or later proves fatal to every kind of mechanism."

Rennie was celebrated for architectural taste, as well as engineering skill. The design of the aqueduct bridge over the Lune, at Lancaster, has been ascribed to him. Among his works were the stone bridge of Kelso, which was commenced in 1803, and finished in two years, at the cost of £18.000, and which is 494 feet long, with five elliptical arches; that of Leeds, to which he added an additional arch, 100 feet in span above the Aire; a third at Musselburgh, built across the Esk in 1807, superseding the use of the old Roman bridge which still survives; a fourth of granite and freestone at Newton-Stewart above the Cree in Galloway, a handsome edifice consisting of five arches; a fifth at Boston, consisting of one elegant arch, which crosses the Witham, superseding a very inconvenient and plain one of wood; and a sixth at New Galloway across the river Ken, all of which sufficiently testify his taste and skill in the art of bridge-building.

He was employed by the Indian Government to design a bridge of three arches, consisting respectively of seventy, eighty, and ninety feet span, to cross the Goomtee at Lucknow; but after it had been cast, constructed, and sent out, the Nabob of Oude, inspired by some whim or caprice, would not permit its erection.

Rennie's celebrity as a bridge-builder must always be attached chiefly to his Waterloo Bridge over the Thames, which is certainly one of the finest monuments we possess of British enterprise and architectural skill; yet he was accustomed to boast that, although a humbler effort, "he considered the bridge of Kelso as one of the very best which he ever designed." The former stupendous work, which was completed in 1817, has not altered more than five inches from a straight line in any part of it. His design for a bridge where old London Bridge formerly stood was selected by the committee as the best of thirty plans submitted to them, and of which many were sent in by architects of the highest merit. This bridge, which was completed by Sir John Rennie and his brother George from their father's designs (for Rennie himself did not live long enough to see them executed), consists of five arches of Aberdeen granite, the central one having a span of 150 feet. He was also the architect of the Southwark iron bridge, which was opened for traffic in 1818.

Among those canals which he personally superintended, we may mention the Lancaster canal, the Aberdeen, which connects the Dee and Don, the Grand Western, the Kennet and Avon, the Birmingham, the Portsmouth, the Worcester, and several others. Besides plans for the West India Docks at London, he executed others for the construction or improvement of docks at Hull, Greenock, Leith, Liverpool, and Dublin; together with harbours at Berwick, Dunleary, Holyhead, Howth, Newhaven, the Queen's Ferry on the Forth, and some others, the mere enumeration of which would prove tedious. In addition to these useful naval works, he designed various important improvements on the Royal dockyards at Portsmouth, Sheerness, Chatham, and Plymouth, and the new naval arsenal at Pembroke was constructed from his plans; but the greatest of all his works is unquestionably the Breakwater at Plymouth, a description of which would far exceed the limits of this brief memoir. Suffice it to say, that it consists of three continuous parts, a centre of 1,000 yards in length, with two wings of 350 yards each, diverging from the centre at an angle of 20°. The low-water line is, however, one mile in length. The top is 45 feet broad; about 500 yards of the central division rests on the Shovel Rocks. The anchorage within has fine holding ground, and a depth at low-water spring-tides of from 5 to 7 fathoms. According to the original estimate of Rennie and Whidby, 2,000,000 tons of stone were required to complete the plan; but by 1811 more than 3,500,000 tons had been deposited: the original estimated cost was £1,013,900.

He made a design for a new naval arsenal at Northfleet, on the Thames; but the sum of eight millions required for the work was considered by Government as too great to be expended upon it. In addition to this somewhat bare enumeration of Rennie's useful and scientific labours, we may add his drainage of the tracts of marsh lands on the borders of the Trent, the Witham, and New Welland, and his plan for draining the Bedford Level, which was but partly carried into execution. "These various public concerns (to quote Brewster's Encyclopædia) are said to have cost little less than fifty millions sterling, nearly twenty millions of which were spent under his own superintendence."

Although Mr. Rennie was of a robust and fine commanding figure, and of corresponding strength of constitution, yet during the latter years of his life he was afflicted with inflammation of the liver. On going to France in 1816, after Waterloo opened up the Continent to British tourists, he declared it was the first relaxation he had taken for thirty years. The disease under which he laboured began ere long to assume a more serious form, and he died in his sixtieth year on the 16th of October, 1821. His remains lie in St. Paul's, near those of Sir Christopher Wren, and under a plain granite slab. Many biographies have appeared of him since then, and a eulogy, soon after his death, was written upon him by M. Charles Dupin. An excellent bust of him was executed by Chantrey, and two able portraits were painted by his countryman, Sir Henry Raeburn, President of the Scottish Academy.

His plans for the improvement of Sheerness, and the final construction of New London Bridge, were ably carried out, as already stated, by his sons George and John, now Sir John Rennie, who was knighted on the opening of the latter work in 1831, and who is so well known in connection with many railway operations, the drainage of the Lincolnshire coast at the Wash (where operations were commenced by his father), the construction of new docks at Whitehaven, the harbour at Ramsgate, and other similar works of equal magnitude.

In closing this sketch, it should not be forgotten that George Rennie, brother of the great engineer, was one of the most eminent of Scottish agriculturists, the chief patron of Meikle, who invented the drum threshing-machine, a useful discovery claimed by more than one person, and whose reputation as a successful and scientific farmer was known over the whole of Scotland, and formed an incentive to the most intelligent agriculturists in that kingdom.

OPTICAL INSTRUMENTS.—XIV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

The Lime-Light.—Next in importance to the electric stands the "lime-light," so called because it emanates from a ball, cylinder, or tablet of lime, rendered *incandescent* by means of a jet of oxygen blown through the flame of a spirit-lamp, or a house gas-burner, or by an ignited mixture of oxygen and hydrogen gases. When the first method is employed, it may be distinguished as the oxy-spirit jet; and when the second is used it may be called the oxy-house-gas jet; both of these, however, are usually known as the "oxy-calcium light." The third method is called the "oxy-hydrogen light," whether pure hydrogen or carburetted hydrogen (house-gas) be employed.

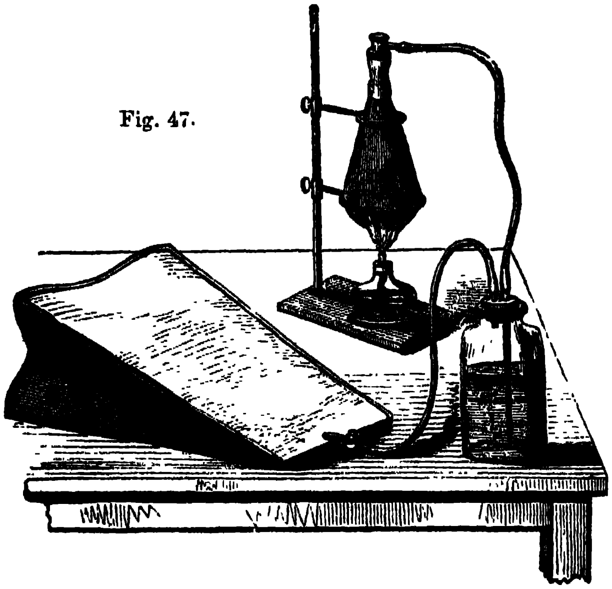
Fig. 47.

The lime-light has also been called after the names of persons: thus we have the "Drummond light," through Lieutenant Drummond having employed it in 1826[*] for signalling while conducting the Ordnance Survey of Ireland and Scotland. When the two gases are *mixed* in a bladder or other receptacle, it is called "Gurney's apparatus;" when the gases are condensed in metal reservoirs, it has been called "the Fitzmaurice light." Then we have the "Bude light," likewise invented by Gurney, where a little ball of lime is suspended over the flame of an argand burner by a platinum wire, supported and rendered incandescent by a jet of oxygen impinging on it, though this name is also given to a simpler arrangement, wherein oxygen under low pressure is passed into the centre of an argand burner fed with highly carbonised oil. Most substances fuse, melt, and are vaporised under the high temperature of the oxy-hydrogen blow-pipe; but lime is one of the few bodies that remains infusible under its action, when it becomes so intensely and luminously incandescent, that the unprotected eye cannot bear to look on it for any length of time. As the ignited mixture of oxygen and hydrogen gives but a feeble blue light, and the true source of light is the lime itself, it is palpable that the most correct generic term for all such arrangements must be the "lime-light," and not "oxy-calcium" or "oxy-hydrogen" light, as we frequently see it called. The lime-light is intensely brilliant, and so purely white in tint, that objects appear in their natural colours, as when seen by day. It is free from all unpleasant or deleterious exhalations, and as no chimney-glass is employed, its heat, like that of the electric light, is diffused into the surrounding atmosphere, so that when confined in a lantern or other apparatus no inconvenience is experienced from the furnace-light heat that argand burners give rise to. As this light is due to incandescence and not to combustion, it may be confined in air-tight glass vessels for use in mines or under water, and as it is not dependent upon a surrounding atmosphere for a supply of oxygen, it consequently presents hygienic advantages if employed in the illumination of buildings, factories, art galleries, etc. The manipulation of the light itself is simple and cleanly, the drawback, in this country, being the necessity for preparing the gases, or at least the oxygen. In Paris and America both oxygen and pure hydrogen are prepared on a large scale, and supplied to the public at a very cheap rate, while in New York oxygen can even be laid on to the houses, where desired, in the same way that we treat carburetted hydrogen, not only for improving illumination, but for sanitary purposes, to neutralise the miasma of fevers, etc. In places where the gases are made on a large scale, the cost of working lime-light apparatus would be insignificant; nor for the intensity of the light obtained, can this source of light be regarded as expensive, even when the gases have to be made at home. I will proceed to describe the component parts of the lime-light apparatus, which embraces the lime cylinder, hydrogen and oxygen gases, their receptacles, the jet, and safety arrangements.

Lime cylinders are of two qualities, "soft" and "hard." The first is made of ordinary unslacked lime (chalk lime), and is best suited for oxy-calcium jets, with which a lower pressure of oxygen gas is employed; the second is made from magnesian limestone, and is used with the mixed gas jet when high pressure is employed. Soft limes are turned into cylinders of about ¾-inch diameter, and 1¼ inch in length. Hard limes are about 1 inch in diameter and 1½ in length. Through the exact centre of each cylinder a hole is drilled, by which it is fitted to the lime-pin of the jet. It is very important that these cylinders should be turned quite true and of a given gauge, such as those given, as it saves a great amount of adjustment when in use. Both soft and hard limes are hygroscopic, or possess a strong affinity for damp, and therefore are very subject to "slack," that is, imbibe moisture, swell, and then break up into slacked lime. It is best, therefore, to preserve lime cylinders in air-tight cases, all vacant spaces being filled up with dry washed sand. Even when packed in metal tubes, just a size larger than the diameter of the lime cylinders, closed with screw-caps and metal "washers," I have known the limes to swell from previously imbibed moisture, and burst the tubes; and it is a very common thing to find the ordinary tin canisters in which a dozen cylinders are sent out from the shops, burst open at the soldered joints, if put aside for a time without having taken the precaution to warm the limes and powder, and paste a strip of paper round the edge of the lid. The preservation of limes is an important question, especially when a large stock has to be sent abroad, and the recipients would be placed *hors de combat* for some months, should the cylinders "slack." The best and simplest way to meet the danger is, I find, to warm *freshly-turned* lime cylinders, and then, in a dry room, wrap each in a strip of waxed paper (made by melting a wax or paraffine candle over a sheet of thin foreign letter paper, and spreading it evenly over the surface with a flat iron), and turning in the ends so as to make an air-tight casing, then to wrap up half a dozen of these in a cylindrical roll of waxed brown paper, and pack them in flat tin cases, large enough to hold a gross or half a gross of cylinders thus preserved. A neat way to preserve small quantities, say a dozen, when freshly purchased, is to suspend them by a thread, and dip each into a solution of india-rubber in benzole; the spirit quickly evaporates, and leaves a thin covering of caoutchouc, which effectually preserves each cylinder, if properly done.

Stout brass tubes, with deep screw-caps and tin-foil washers, make the best and neatest lime-boxes. This tendency to slake has induced experimenters to seek other suitable substances. Magnesia mixed with plaster of Paris, worked with water into a smooth paste, and cast in wooden moulds, and then baked, has been recommended; but even when these have been hardened by bi-silicate of potash being added to the water, I find such cylinders do not stand under the oxygen jet. Meerschaum, a silicate of magnesia, answers better, but the drawback is that it produces a pinkish tint when rendered incandescent. Magnesia, rendered perfectly pure, and condensed into a small compass by means of the hydraulic press, has been used in France by M. Tessié du Mothay, but specimens I have tried "pit" deeply and quickly, on being subjected to the ordinary pressure employed with English jets. Probably, if the magnesia were compressed as thoroughly as chemical compounds are capable of being condensed by Brockedon's patent process, this defect would be surmounted, but the apparatus required is of a costly description, and that in existence is now not in work.

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[*] The lime-light was employed as far back as 1820.

Monckhoven has recommended compressed cubes of magnesia containing embedded titanate of magnesia, which I have tried, but cannot say I feel impressed with their great superiority. Monckhoven states that "a compound made up of 10 parts of pure carbonate of magnesia, 2 of charcoal, 1 of chloride of titanium slightly damped, worked in a mortar, and compressed into pillars, gives a light almost twice as brilliant as the one above described, but costs ten times the amount." M. Soret has invented an artificial stone of great hardness, which would probably answer admirably for lime cylinders. It is an insoluble compound of chloride of magnesium and magnesia, formed by combining calcined magnesia with a saturated solution of chloride of magnesium, and allowing it to set in moulds. Du Mothay has lately introduced small discs of zirconia embedded in cylinders of clay or other cheap infusible supports. Oxide of zirconium is the most infusible, the most unalterable, and the most luminous of all the chemical substances at present known, when exposed to the action of the oxy-hydrogen jet; so it is in this direction we must look, in the hope of surmounting the drawbacks connected with the hygroscopic character of lime. I may here state that, though such preparations might at their first purchase seem costly, they would in the long run prove the most economical,* and be the greatest boons and comforts the lecturer could secure. Du Mothay thus describes his method of preparing zirconia:—"To obtain zirconia in a commercial state, I extract it from its native ores by transforming by the action of chlorine in the presence of coal or charcoal the silicate of zirconium into double chloride of zirconium and of silicium. The chloride of silicium, which is more volatile than the chloride of zirconium, is separated from the latter by the action of heat; the chloride of zirconium remaining is afterwards converted to the state of oxide by any of the methods now used in chemistry. The zirconia thus obtained is first calcined, then moistened, and submitted in moulds to the action of a press with or without the intervention of agglutinant substances, such as borax, boracic acid, or clay. The sticks, cylinders, discs, or other forms thus agglomerated, are brought to a high temperature, and thus receive a kind of tempering or preparing, the effect of which is to increase their density and molecular compactness. I can also compress in moulds shaped for the purpose a small quantity of zirconium capable of forming a cylinder or piece of little thickness, which may be united by compression in the same mould to other refractory earths, such as magnesia and clay."

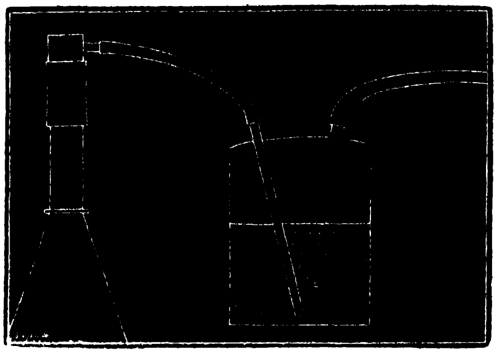

Fig. 49.

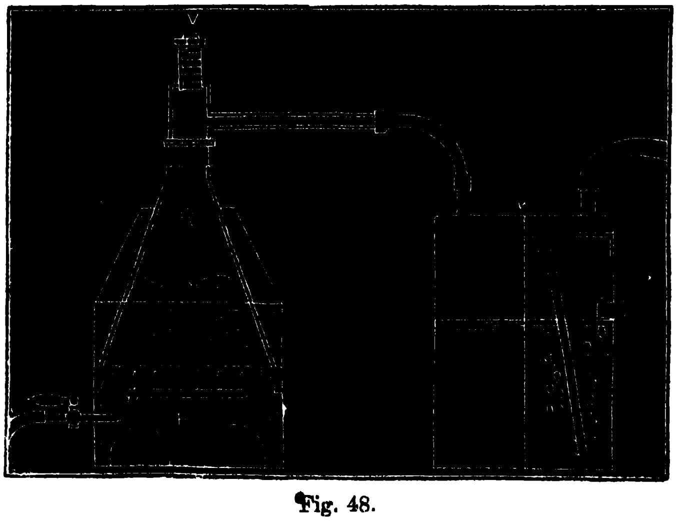

Fig. 48.

For the purposes of photographic enlargements by means of the oxy-hydrogen jet, Professor Carlevaris of Genoa employs little cubes of retort carbon (such as is used with the electric light) saturated with chloride of magnesium; this produces a very actinic light when subjected to the oxy-hydrogen jet, but the chloride is quickly decomposed, and nothing remains but the ignited charcoal, so that this is not suited for a continuous light, though suited for short exposures in photographic enlargements. Should an exhibitor be awkwardly situated by finding his stock of limes injured by "slacking," he may meet the difficulty by getting a lump of quick-lime, and sawing it into cubes, then use one face after the other, sliding the mass up instead of round; or cylinders may be made by shaping the lime into hexagonal pillars, and then rounding off the edges with a rasp or coarse file. In either case the central hole may be made with "a rat-tailed file."

Oxygen Generating Apparatus.—Of the various methods employed for obtaining oxygen gas, the one most generally adopted is that of heating a mixture of chlorate of potash and oxide of manganese. In this process the oxygen is derived from the chlorate of potash, not from the manganese, which simply acts mechanically, not chemically, as sand, a non-oxygen producing body, may be used in its place. Practically, one pound of chlorate of potash yields four cubic feet of oxygen, though the text-books would lead us to look for a yield of five cubic feet from that quantity. Were we to treat the potash salt *per se*, the oxygen would rush from the retort with force: to subdue this violent action, we use the manganese, or any other suitable substance that will, as it were, mechanically dilute the mass of the potash salt; consequently a fixed proportion between these two substances is not essential, and may be varied from equal parts to 1 part of manganese to 4 of potash; though the proportion that allows the oxygen to come over neither too fast nor too slow, is 1 part of manganese to 3 of potash. If, therefore, we wish to produce six cubic feet of oxygen gas, we take a pound and a half of chlorate of potash, and mix with it half a pound of oxide of manganese. It is often directed to use the manganese in fine powder; this I found to be a grave mistake, as it tends to float on the surface of the melted potash, and on the oxygen coming over, it carries the fine powder in a damp condition into the delivering tubes, and blocks them. It is, therefore, better to use the manganese in coarse grains. The chlorate of potash should not be powdered, but left in its crystalline state, the larger crystals alone being broken, and then intimately mixed with the granular manganese. If the manganese is washed from the potash after each operation and then dried, it may be used over and over again, and apparently with advantage, as the oxide in its brown state after ignition seems to answer better than the original native black peroxide of manganese. Care must be taken that the mixture never becomes contaminated with organic matter in any shape, or it may lead to serious explosions. A few years back a death was occasioned by the manganese getting accidentally mixed with soot or some carbonaceous matter, and another explosion came to my knowledge (fortunately without serious result) through a small portion of india-rubber tube melting and running into the retort. In the ordinary method of manipulating, the mixture is placed in a conical retort (made of iron or copper), which is closed with a large vulcanised rubber tube that serves as a safety-valve; from this passes a tube that is connected with the dip-tube of a wash-bottle, as shown in Fig. 47.

On heat being applied to the retort, the gas passes over into the water in the wash-bottle, and is there freed from dusty particles and other impurities; on rising from the water, it passes out from the short exit-pipe into a gas-bag or other receptacle. In unpractised hands, this arrangement leaves the road open to certain mishaps. I have, therefore, re-arranged the oxygen-generating apparatus in such a manner as to provide against every contingency, a matter of importance when such appliances have to be provided for amateurs, who only use their apparatus a few times in the course of the year, and consequently cannot be reckoned on as practised manipulators.

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* When the mixed gases are used under great pressure, clocks, to keep the lime in constant motion, are a necessity, but an indestructible cylinder would dispense with their use.

My apparatus consists of a retort, a jacket-furnace, and a safety wash-bottle, shown in Fig. 48. The retort, R, may be made of iron or copper, conical in shape, with a flat bottom and wide neck, into which screws a brass cap fitted with a stout delivering-tube, and a safety-valve, V, formed of a tube, closed with a good cork covered with tin-foil, which, in the event of the delivering tubes becoming choked, yields and gives vent to the gas. The furnace, F, may be arranged for gas or charcoal, the former being the most convenient, as it allows of the amount of heat being increased or decreased at will, by the control of a stop-cock. It is made of sheet iron, and the upper part corresponds to the shape of the retort, which prevents a great amount of heat being dissipated, and secures the upper surface of the oxygen mixture being quickly melted as well as the substratum immediately over the flame. This corrects the evil arising from the tendency of the light particles of the manganese to float on the surface of the melted potash, previously referred to, which was the cause of the delivery-pipes becoming choked. After the mixture has become thoroughly melted, it not unfrequently happens that the oxygen comes over with a rush (especially if only a small allowance of manganese has been employed), instead of in a quiet, orderly manner, and then something may give way—it may be the safety-valve, or it may be the india-rubber connecting tubes, or the retort itself might "rip;" but by means of the stop-cock, or by lifting the furnace off the pan of charcoal, all violent action may be at once subdued; and by the same means provided in this arrangement, should the action become too torpid, it may be stimulated to the desired rate of delivery. Another source of accident arose, if the operator did not disconnect his retort from the wash-bottle as soon as all the oxygen was given off from the mixture; for nature, abhorring a vacuum, sucked up the water from the wash-bottle, and on its coming into contact with the red-hot residue, became converted into steam, and an explosion terminated the operation. This arose from the delivery-pipe of the retort passing directly into the water of the wash-bottle, as shown in Fig. 49.

To provide against this accident, I divide my wash-bottle into two compartments, and arrange the tubes so that the one connected with the retort does not come in direct communication with the water, as shown in Fig. 48. A shield at the exit-pipe of the wash-bottle prevents the spray being blown over into the gas-bag placed to receive the gas. This bottle is filled with water till it is two-thirds full. At this height a vent-hole, plugged with a cork, is placed, to allow of the bottle being emptied and cleaned out. The delivering-tubes should be about ½-inch in the bore, and the connections should be made with red-rubber tube, which stands the best, and is free from the unpleasant smell common to ordinary vulcanised india-rubber tubing.

TECHNICAL DRAWING.—XLIX.

GOTHIC STONEWORK.

GENERAL DIVISIONS OF ECCLESIASTICAL BUILDINGS.

IN order that the position of the details forming the subjects of the following lessons may be clearly understood, it is necessary to explain some of the terms which are employed in relation to the churches or other buildings which exemplify them.

Most of the ecclesiastical structures of the Middle Ages were built in the form of a cross, with a tower or spire erected at the intersection. The interior was usually divided thus:—

The Nave.—The space westward of the central tower—the body of the church—reaching from the choir to the principal door. This name is applied equally to the body of the church, whether the plan is that of a cross or not, and whether with or without aisles.

The Aisles (from the French *aile*, "a wing").—The spaces outside the piers of the nave, choir, or transepts, and forming a passage or alley on each side of the nave extending to the outer wall of the building.

Choir.—The space eastward of the central tower—the continuation, as it were, of the nave on the opposite side of the base of the tower. In the early Christian churches it was simply part of the nave enclosed by a low wall, and forming a place in which the singers who chanted the services sat; hence the name (Latin, *chorus*; Italian, *coro*; French, *chœur*; German, *chor*; Old English, *quire*).

Transept.—That portion of a church which passes across the nave and choir, and thus forms the two arms of the cross in the plan, the central tower standing on the intersection. Commonly each arm is spoken of as a separate (as north and south) transept, although, strictly speaking, the transept is one. Transepts, in most instances, match each other exactly, or are in pairs. At Exeter are two noble Norman towers, which are supposed to have been the western towers that flanked the original Norman front. At Chester one transept is of Norman work, while the other is of the Decorated period, and is much elongated. It is supposed to have been built as a separate church, and it is thus used at the present time.

The choir is generally enclosed by a *screen*, on the western part of which is usually placed the organ; which is now, however, often placed on one side of the church.

The choir in cathedrals does not generally extend to the eastern part of the building, but there is a space behind the altar called the *Lady Chapel*. (The Lady Chapel is not always at the east end of the choir. At Durham it is at the west end of the nave, and at Ely at the north side.)

The choir is only between the piers, and does not include the side aisles, which serve as passages to the Lady Chapel, altar, etc.

Chancel.—A part separated from the rest of the church by a screen (*cancellus*). The term is now used to signify the choir of a small church.

The Apse.—The semi-circular or polygonal termination to a church. These forms were, no doubt, derived from the *concha* or *bema* in the classic and early Christian basilica.

Porches are covered erections, forming a shelter to the doors, which have sometimes vestries, schools, etc., over them.

Chapels are attached to all parts, and are frequently additions.

The Chapter House is the chamber in which the chapter, or heads of the monastic bodies, assembled (as the Dean and Chapter now do) to transact business. They are of various forms; some are oblong apartments, as Canterbury, Exeter, Chester, Gloucester, etc.; some octagonal, as Salisbury, Westminster, Wells, York, etc. That at Lincoln has ten sides; that at Worcester is circular.

Cloister.—An enclosed quadrangle, with a walk or ambulatory round it, sheltered by a roof generally groined, and by traceried windows, which were more or less glazed. Cloisters were used for exercise in bad weather, and for reading and meditation in the shade, when the season was hot. They also formed a covered communication between different parts of the monastery. The usual place for the cloister is the south side of the nave. At Canterbury, Gloucester, and Chester, however, they are on the north.

Any building above the roof may be called a *steeple*. If it be square-topped, it is called a *tower*.

The tower may be round, square, or multangular. It is often crowned with a *spire*, and sometimes with a short tower of light work, called a *lantern*. An opening into the tower in the interior above the roof is also called a lantern. When a tower is of great height, in proportion to its diameter, it is called a *turret*. These often contain staircases, and are frequently crowned with small spires.

Clearstory, or *Clerestory.*—When the middle of the nave of a church rises above the aisles, and is pierced with windows, the upper storey is thus called. Sometimes these windows are very small, being merely quatrefoils or spherical triangles. In large buildings they are important objects, both for beauty and utility. The windows of the clerestories of Norman work, even in large churches, are of less importance than in the later styles. In Early English they become larger, and in the Decorated are more important still, being lengthened as the triforium diminishes. In Perpendicular work the latter often disappears altogether, and in many later churches, as at Taunton, the clerestories are close ranges of windows.

Triforium.—The arcaded storey between the lower range of piers and arches and the clerestory. At Durham and Westminster it is called the "nunnery," and the tradition is that the nuns sat there during the services, hidden by curtains, which is not at all improbable, since this is even now the case in some churches at Rome.

Presbytery.—That part in the chancel of the church set apart for the officiating priests.

Crypt (sometimes called the "Undercroft").—The vaulted apartment beneath a church, either entirely or partly under ground. Crypts owe their origin to the circumstance of the early Christians being compelled, for the sake of secrecy and concealment, to perform their sacred services in caves and subterranean places, some of which are still pointed out at Rome. Crypts are not unfrequent, especially under large churches. They seldom, however, extend the whole length of the church, being usually confined to the choir or chancel, and sometimes not extending so far as this. They are usually low and massive, of an earlier and plainer style than the superstructure.

Crypts were formerly used for service, and accordingly are provided with altars and other furniture requisite for the purpose. The most extensive building of this kind is that under Canterbury Cathedral, a portion of which is said to have been built by Lanfranc, in the time of William the Conqueror. The south-west corner of the crypt is called the French Church, which is still used for Divine service.

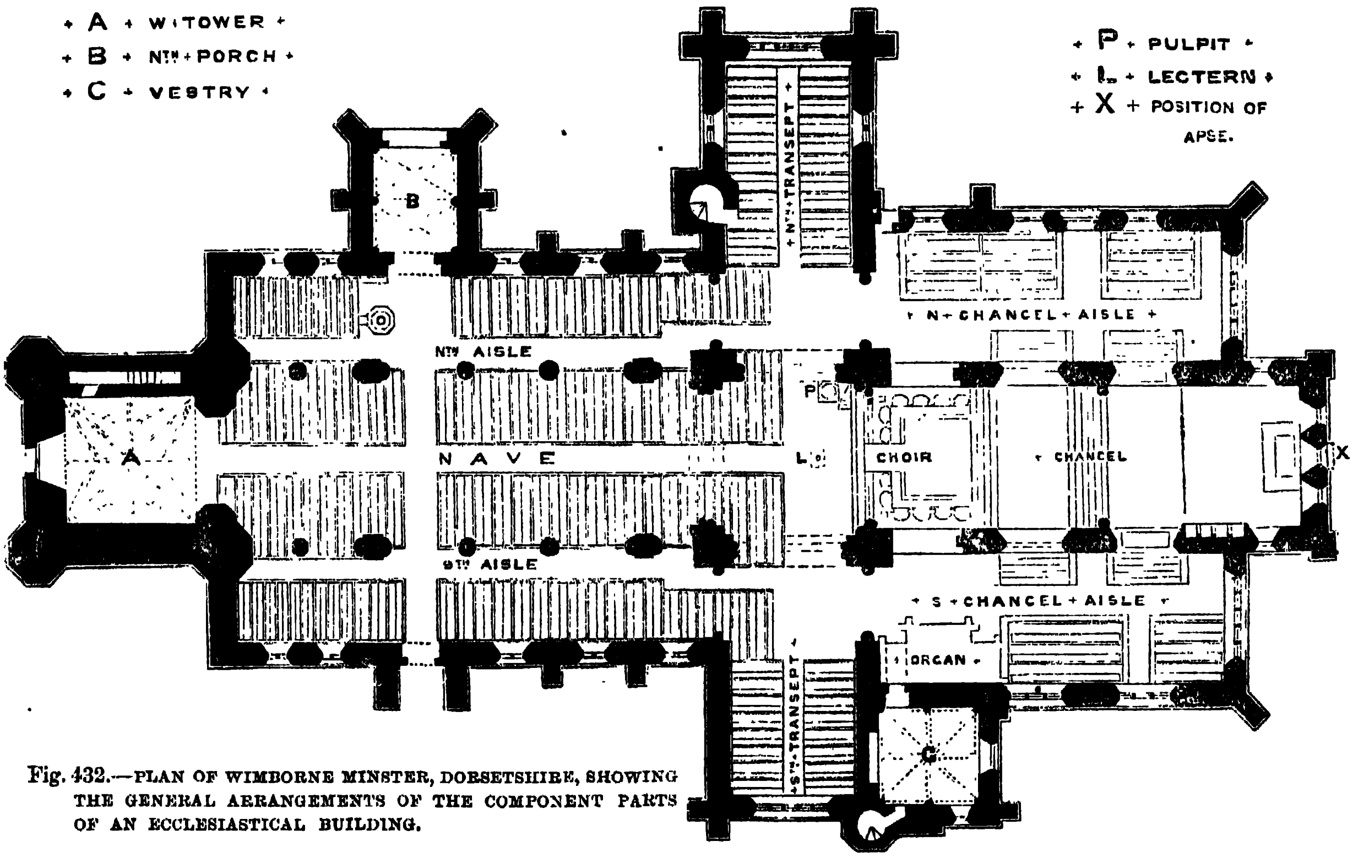


Fig. 432.—PLAN OF WIMBORNE MINSTER, DORSETSHIRE, SHOWING THE GENERAL ARRANGEMENTS OF THE COMPONENT PARTS OF AN ECCLESIASTICAL BUILDING.

The following sketch of the internal arrangement of a church is quoted from Mr. Peter Nicholson:—

"On entering the church through the wicket at the entrance of the porch, we sometimes notice on the right-hand side of the door, often projecting from the wall, and partly covered by a niche, a stone basin, which is called a *stoup* or *aspersorium*, from its use, which was to contain the holy water with which, in olden times, the worshippers sprinkled or crossed themselves before entering into the body of the church. This was a very ancient practice, and was adopted in a somewhat different shape by the early Church; the small stoup, in fact, is a substitute for the fountain to be seen in front of the Constantinian churches, at which Christians were accustomed to wash before entering the sanctuary. The custom is typical of the purity of mind which should accompany our devotions.

"Before proceeding further, we may notice the stone seat or bench-table, which runs along the sides of the porch, and is occasionally covered with an arcade, and sometimes surmounted with a window to give light to the porch. In ancient times several religious ceremonies took place in the porch, especially those preliminary to baptism and matrimony. Having passed under the inner arch of the porch, we are now fairly in the church, and the first object to attract our attention is the *font*, which is placed near the principal entrance. The exact locality is not fixed, being sometimes in the central avenue of the nave, opposite the entrance, and at others under one of the arches of the aisle, near the porch, in which case it frequently adjoins one of the adjacent pillars. It is not unfrequently raised on a series of steps, which give it a more imposing appearance, and has always a space left around it for the accommodation of the priest, sponsors, etc.; for the former there is sometimes a kneeling-stone on the west side. Fonts in a perfect state are provided with covers, generally of wood, some flat and others of a pyramidal form, more or less enriched. We here speak of fonts as they were in former times, not as they are now found in old churches; for the original ones are sometimes not only moved from their ancient positions, but even taken out of the church, and altogether discarded. On proceeding further into the church, the next object which probably strikes our eye is the *chancel*, and at its extremity the *altar*, with its appendages; but as this has been described in its proper place, we shall not stop to reconsider it here; and besides this, in fixing our attention on the more striking portion of the edifice, we have overlooked the pulpit. Few pulpits are to be met with of an earlier date than the fifteenth century; the oldest that remain are of stone, built up with the fabric, from which circumstance we may infer that they are coeval with the entire structure. There is a beautiful specimen at Beaulieu, Hants, which is attached to the wall, and entered by a staircase partly cut out of its thickness; another specimen is to be found in the Church of the Holy Trinity, Coventry, which is attached to one of the piers of the building. The later pulpits are of oak, usually of an octagonal form, having the sides panelled and enriched with carving, and the whole sometimes surmounted with a richly-groined canopy projecting over the head of the preacher. The position of the pulpit was probably always at the north-east or south-east end of the nave, near the arch which separates the nave and chancel."

SILK CULTURE.—I.

By ALEXANDER WALLACE, M.D.

VARIOUS WORMS PRODUCING SILK—CONDITIONS NECESSARY FOR SUCCESS IN SILK CULTURE—LIFE OF THE INSECT: THE EGG STAGE.

SILK, generally, is a material obtained from a sort of pod or purse, that remarkable envelope which many kinds of caterpillars make (especially in the family of the Bombyces), of more or less value and quantity, and which they weave around themselves preparatory to the change from the caterpillar into the chrysalis state. This pod when of a superior kind, and especially such as is obtained from domesticated worms, is distinctively termed a cocoon, and silk culture consists in the cultivation of those races which spin cocoons possessing a commercial value.

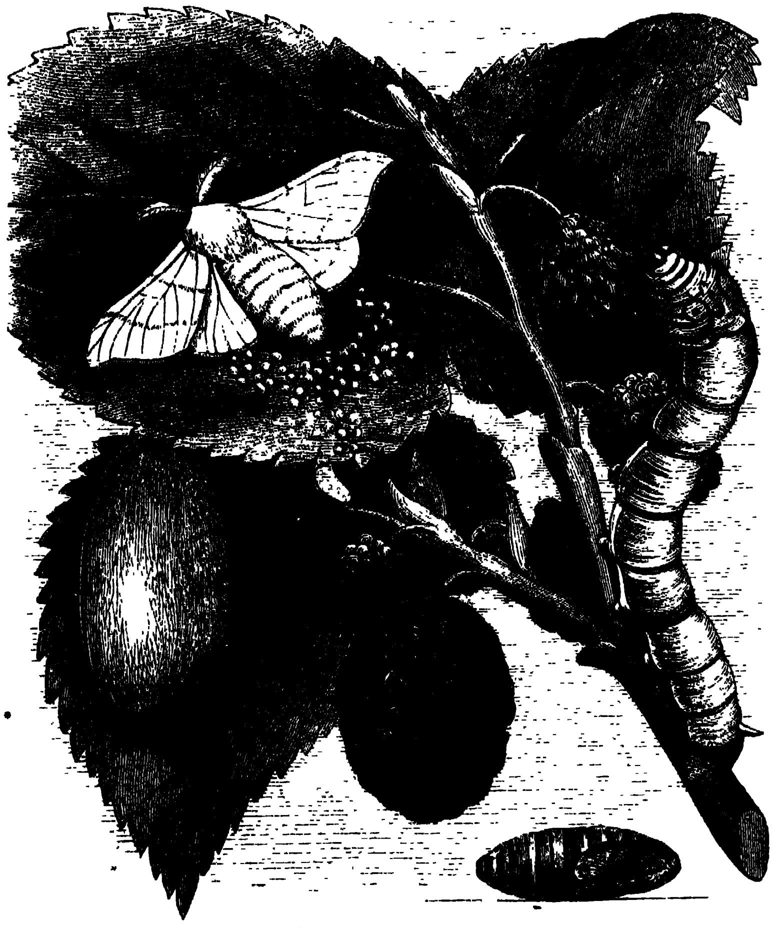


Fig. 1.—CATERPILLAR, COCOON, CHRYSALIS MOTH, AND FOOD OF BOMBYX MORI.

The following races of Bombyces produce cocoons which are more or less used in the production of silk-fibre :—

1. The *Bombyx mori*, or mulberry-worm—the only domesticated species; the silkworm of commerce, from which the great bulk of silk is obtained.

2. The *Bombyx Yama-Maï*, or Japanese oak-feeding silkworm, producing a greenish cocoon, from which a good thread may be reeled, highly valued by the Japanese for certain purposes—especially for embroidery, in which they are greatly skilled.

3. The *Bombyx Pernyi* of North China, an oak-feeder, producing a large greyish-brown cocoon, which has been reeled in China, but not yet in Europe.

4. The *Bombyx Cynthia*, feeding on the *Ailanthus glandulosa*, from China and Northern Asia; this also produces a long greyish cocoon, not reeled in Europe, but undoubtedly reeled in China, whence is obtained a peculiar silk, easily recognised by its extreme softness. Silk in piece goods made from these cocoons and from those of *Bombyx Fernyi*, is plentiful and cheap in the Chinese markets of the interior, and therefore may some day be fabricated in Europe.

5. The Tussur Moth (*Antheræa Paphia*) of India makes a large, very hard, dirty greyish cocoon; this is reeled by the natives to form the Tussur silk, well known in the Indian markets.

6. Allied to *Bombyx Cynthia* is the *Bombyx ricini* from Bengal, feeding on the castor-oil plant (*Ricinus communis*), producing a cocoon smaller, but very similar to that of *Bombyx Cynthia*.

7. Cocoons of other Bombyces, such as *Polyphemus*, an oak-feeder; *Cecropia*, a plum-feeder—both from North America; *Hesperus* from Cayenne, feeding on the *Cafe du Diable*; *Faidherbia Baubiniceæ*, feeding on the *Cytisus cajanus*; *Bombyx fauvetyi*, from Uruguay, feeding on a species of *Mimosa*; *Pachypusa effusa*, also a *Mimosa*-feeder, from the Cape; *Attacus Atlas*, North India, feeding on the *Berberis Asiatica*; *Antheræa Roylei*, feeding on the evergreen oak of the Himalayas, etc. etc., have all been more or less the subject of experiment, but as yet none have been found sufficiently easy to reel; though doubtless most of these cocoons, if obtainable in large quantities at little cost, would be worth carding, and produce a useful, though perhaps not a very ornamental fabric.

The culture of the *Bombyx mori* is of very ancient origin. It is said that an empress of China, 3,000 years before the Christian era, was the first to unravel with delicate fingers the filmy thread from the cocoon, and dexterously to weave it into a beautiful web of cloth. The art was for a long while confined to the East, but about 550 A.D. two monks, having procured in India the precious eggs, concealed them in a hollow cane, and hastened to Constantinople. Thence silk or sericulture spread in all directions, and is now a most important and staple industry in Central and Southern Europe, extending to a slight extent into Germany, Sweden, and even into Great Britain, where endeavours have from time to time been made with some success to cultivate the worm.

Turkey, Egypt, Asia Minor, Persia, India, China, and Japan transmit large supplies of cocoons and of raw or reeled silk. Australia, the Cape of Good Hope, New Zealand, the Sandwich Islands, West Indies, and other of our colonies are waking up to a sense of the capabilities they possess of turning this very lucrative industry to advantage; while California, Russia, Chili, Turkestan, and other countries are commencing to draw large profits from sericulture. The conditions necessary for success in silk culture are—

1. To have a healthy, vigorous plantation of mulberry-trees. These generally thrive best on hilly sites, where the soil is light and gravelly; but they will grow almost anywhere, and in China have been seen planted like our willow pollards by the sides of streams. Several kinds of mulberry are used in silk culture. The *Morus nigra*, or common black, grows most luxuriantly at the Cape, but elsewhere it is generally rejected because of its slow growth; it does, however, very well for the early worms. The *M. alba*, or white mulberry, is the variety generally used in Europe; the rose-leaved variety being preferred in Italy, on account of its large, stout leaf. *M. Alpina* is suitable in some localities, as being a very hardy variety. A large-leaved kind, *M. Japonica*, recently introduced from Japan, is also much esteemed. *M. Moretti*, another Italian variety of high repute, and *M. multicaulis* from the Philippine Islands, possessing a thin, concave, but very large leaf, are also much grown. The latter being a very early kind, is used mainly for the young worms; its leaf is unfit for the elder worms, being thin and watery.

After a plantation is made, it should be left three years before any leaf is taken for feeding purposes, so as to give the trees time to get well established.

2. The next point of importance is the arrangement of the buildings or *magnaneries* in which the worms are "educated." These should be moderately lighted, and very well ventilated both by night and day. An even temperature, and a constant

current of pure air passing through without draughts, are of the utmost importance to the worms. The thermometer and hygrometer must be constantly watched, with a view to the maintenance of the proper temperature and dryness. Vermin, especially mice, must be excluded. In this country it will be well for the roof to face north and south, and for windows to look east and west, so as to obtain the greatest amount of sunshine. The interior should be so arranged that easy access may be had to the shelves on which the worms are placed to feed. Dandolo, the best authority, in his book, gives as the dimensions of a small laboratory, 40 feet by 18 feet by 12 feet high. This would contain a double tier of trays in the centre of the room, and a single tier round the sides; but as it is preferable to have a passage all round the trays for the sake of convenience, as well as for ventilation, it would be wiser to add 4 feet to the width, and also to the length, making it 46 feet by 22 feet, so as to hold two double rows of trays; or by adding another 6 feet in width and 2 in length, making the *magnanerie* 44 by 30 feet, ample room may be obtained for three double rows of trays with a passage on either side of them.

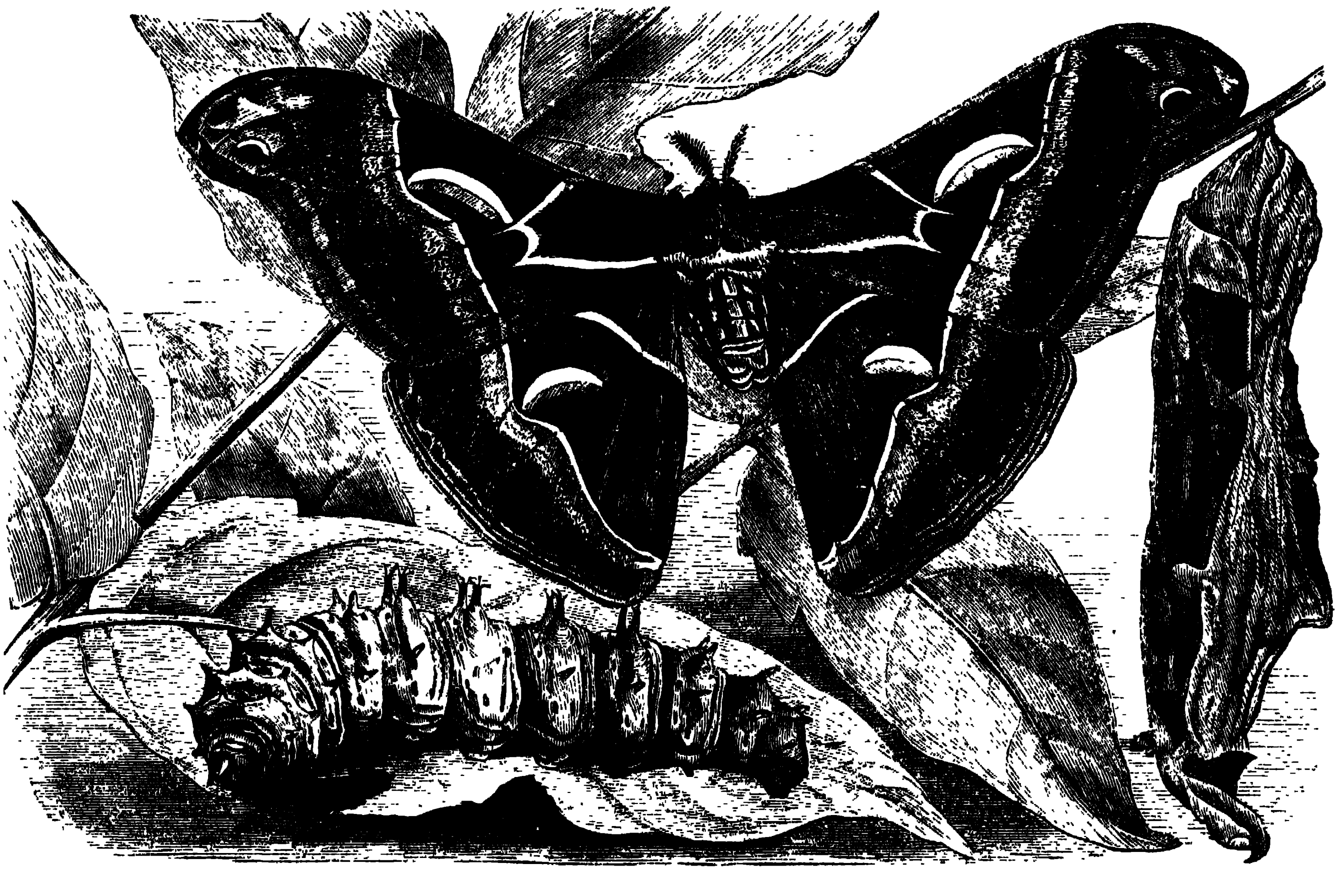


Fig. 2.—CATERPILLAR, COCOON, MOTH, AND FOOD OF BOMBYX CYNTHIA.

The unit, as it were, of measurement is the size of a sheet of stout double-glazed brown paper, viz., 45 × 29 inches, which is laid for the floor of each tray of worms. The inner measurement of each tray will be the same. Strong twine netting, of about 1 to 1½ inch mesh, is tightly strained across and fastened to the sides of each tray. It is a good plan to lace the nets tight with twine or strong thread to binding, fastened to the wood by means of tacks. A twine floor is far preferable to the boarded floors, which are much used in France, on account of its superior ventilation, preventing mould, which is very injurious to the worms. The trays may be about 16 to 18 inches apart vertically, the lowest about 6 inches from the ground, ascending as high as convenient, even to the top of the room, though in that case special means of ventilating the upper stratum of air must be devised, and a convenient ladder on castors be provided for moving round the room without noise, high enough to enable those in charge to attend to the worms on the higher tiers. Practically, six tiers vertically placed will be found as much as can be managed conveniently. The trays should all be of the same size, and the tiers should be level throughout the room. A table the same size or a little larger than the trays should stand in a convenient well-lighted spot in the centre of the room, where the trays of worms may be placed and carefully examined when necessary.

3. The third point of importance is the purity and sanity of the eggs to be operated upon. It is well known that a peculiar disease, "la pebrine," not yet thoroughly understood, has devastated many of the silk-growing districts, especially in Europe. It is therefore necessary to procure eggs or grain from countries as yet unaffected by the disease. With this view, large imports of eggs have come from Japan, China, and other parts, and the price of good grain has risen from 5s. to 25s. per ounce. In 1869 the total value of eggs imported into France alone for home use was as follows:—From Japan, 9,436,000 francs; Egypt, 1,232,000 francs; China, 560,000 francs. The total value of exports of eggs of French produce was 3,378,700 francs, being chiefly to Italy, the proportion of eggs required by Italy to those required by France being about 5 to 2. This shows the great demand for healthy seed from new countries. For the purpose of rearing sound grain, England is considered by French *savans* to be remarkably adapted by reason of its temperate climate. The Cape, California, New Zealand, and Australia are also especially favoured districts. In fact, the disease is eliminated and quite disappears under proper treatment in the latter country. Mr. Charles Brady, of Sydney, N.S.W., writes: "The mulberry of all varieties thrives here remarkably well; and I have every reason to believe that its silkworm may, even if severely diseased on introduction, some become quite sound by proper treatment under our invigorating atmosphere. My experiments have been uniformly successful, in regard to eliminating disease." I have myself received from Mr. Brady eggs of a celebrated European race (Milanaise), now very subject in Europe to disease, which have been pronounced, after microscopic examination by skilled experts, to be perfectly free from all sign

of disease. It is especially desirable to renovate the old races of the *Bombyx mori*—which have been ennobled in former generations for the quality of their produce, but which are now nearly exterminated from the prevalence of the disease—by importing their grain into new localities where disease is unknown. Settlers in Australia, New Zealand, and similar localities should especially consider what great pecuniary advantages are offered to them from this branch of sericulture. Another point of great importance, in reference to our Australian colonies, is mentioned by Mr. Brady. "I have had silkworms in all stages of their development, from the egg to the imago, every day in the year, and I am able to feed up several generations in the year, and rear a brood at will at any season. Hence we have a remarkable advantage in our climate, in being able to produce many crops a year, or, as it may be otherwise expressed, to spread the season over a large portion of the year, thereby gaining manifold what could otherwise be obtained." In Europe the annual worm having one brood only per annum produces the most valuable cocoon. The "bivoltine," or worm having two generations per annum, is also cultivated, but its produce is inferior. In hot countries, as India, silkworms having three or more generations in the year (such as *Bombyx Sinensis*, a monthly worm) are cultivated; the cocoon in these races, being always smaller, is deficient in quantity, and generally in quality of produce. The annual worm is therefore the most esteemed, and these races, according to Mr. Brady, may in Australia be made to produce three crops of silk per annum without deterioration of the cocoon. This gives a decided advantage to cultivators in that country.

The value of the different races of the *Bombyx mori*, admitting their sanity to be equal, depends on their produce, the cocoon—*i.e.*, on the amount of silk which can be reeled from a given number of cocoons, which should all possess more or less the typical points of the race: viz., the Novi, an Italian race, of which the Moricand is one of the best examples. spins a large, white, oval cocoon; the Milanaise, another very valuable race, spins a large cocoon, smaller than the Moricand, more elongated, of a buff colour; and so on. Japanese races are of different colours—white, buff, green, etc.—but all possess a peculiar property of being nipped-in in the centre, as if the cocoon had been spun in two halves and joined in the centre.

Cocoons which feel hard and firm to the touch possess more silk, and are preferred as having a greater value; thin and soft cocoons are rejected as inferior.

These three main points being secured—viz., a good supply of mulberry-leaves, a suitable *magnanerie*, and eggs of a healthy race of approved value—let us follow the life of the insect, beginning from the egg stage, to the cocoon; and examining the manipulation and treatment employed by *educateurs* in the different stages.

1. *The Egg Stage.*—The old proverb must be borne in mind: A good beginning makes a good ending. If deterioration takes place in the egg stage, vigorous healthy worms cannot be expected; therefore care must be taken even of the eggs. These are deposited by the moths on paper, cloth, or other suitable material. They should be kept in a cool airy room, free from damp, and once a month at least be thoroughly ventilated. The Japanese wrap the cards on which their eggs are laid in paper bags, and hang them to the roof of their dwellings, which, being made of bamboo, are very freely ventilated. During the egg stage alone, races may be transferred safely from one country to another, and the trade in silkworms' eggs has assumed large proportions. In 1869 two millions of cards, costing on an average 12s. 6d. each, were sent to Europe from Japan. Special steamers are chartered to bring home this valuable cargo as speedily as possible; and during the voyage, in suitable weather, the boxes are opened and the contents ventilated. In each box, which is three feet long, and on which a freight of £3 is paid, are packed 200 cards in separate grooves, so as to allow of ventilation between each card, and to avoid friction. Each card contains about five-sixths of an ounce of eggs, and costs from three to four dollars in Japan. It is a matter of the greatest importance to export eggs as soon as possible after they have been laid, and before they have been exposed to any chill from cold weather, especially if they have to travel long distances. Exposure to cold is necessary to set in action vital changes in the egg, which once begun cannot be stopped without deterioration; and a subsequent change to a warmer climate will then hatch out the egg prematurely. This I have proved for several years to be the case with the eggs of *Bombyx mori* and *Bombyx Yama-Maï*, and also with the cocoons of *Bombyx Pernyi*, *Cecropia*, and other races. The only safe rule is to forward eggs or cocoons in the autumn, as quickly as possible; ice in any form is dangerous, and should never be employed.

BUILDERS' QUANTITIES AND MEASUREMENTS.—II.

BY E. WYNDHAM TARN, M.A.

BRICKLAYING.

When the foundation of a building is formed of concrete, as described in the second lesson on "Building Construction," the length, width, and thickness of the concrete are entered under each other in the dimension book, and then cubed, being reduced to cubic yards in the abstract. If, however, the quantity is small, or the thickness less than twelve inches, enter the length and width only under each other in the book, and describe the thickness; it will then be brought into superficial yards in abstracting. State likewise the composition of the concrete, whether made with lime or cement, and in what proportions to the ballast and sand.

When concrete is employed as the material for building walls less than twelve inches thick, enter the height by the width, deducting openings, and bring it into superficial yards in abstracting, describing the thickness and mode of construction; if the walls are twelve inches and upwards in thickness, the cubical contents can be taken as before described.

Brick walls are usually measured by the foot superficial, the length and height being entered under one another in the dimension book, describing the number of bricks of 9 inches long which the wall has in its thickness—as half-brick, one brick, one and a-half brick, two bricks, and so forth. First enter the length of each course of footings separately, by the height of three inches, if there is a footing or set-off at each course, as in Fig. 1; or by a height of six inches, if there are two courses of bricks to any set-off, as shown by Fig. 2, and describe the number of bricks in the thickness of the wall. Then enter the length of the walls by the height, as if solid, taking those of the same thickness together, and stating the thickness in bricks. Where several items of the same kind or thickness follow each other in the dimension book, write the word "add" against them, to save the trouble of repeating the description. Measure all projections of chimney-breasts, etc., in the same way, stating the amount of projection, whether half-brick, one brick, etc. The height and width of each opening are to be entered one under the other, putting the word "deduct," or "ddct." against the item, and stating the thickness of the wall in which it occurs. No deduction is to be made for sills of windows or stone dressings, flues, or for any woodwork bedded or built into the wall; but openings for fire-places are to be deducted.

Fig. 1.

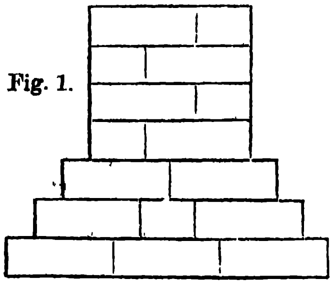
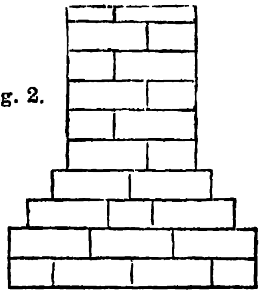


Fig. 2.



To measure the length of the walls in a building which has square corners, take the external girt and deduct twice the thickness of any two of the walls, or else take the length of two walls on the outside, and of the other two on the inside. When the labour only is being measured, the external girt must be taken without deduction.

In abstracting brickwork, rule two columns for additions and two for deductions, writing "1 bk." and "1½ bk." at the head of each; then enter all the measurements from the dimension book in one or other of these columns. Thus a wall 2½ bricks thick will be abstracted twice, and entered under both columns. Add together all the deductions of the same sort, and also all the additions, take the former from the latter, and the quantity of 1 bk. walling and 1½ bk. walling is thus obtained: the former being multiplied by 2 and divided by 3 is brought into 1½ bk. walling, and can be added to the quantity already formed under that heading. The brickwork is now said to be "reduced" to the standard of 1½ brick in thickness, and when divided by 272 is brought into rods.

When the thickness is three feet or more, the brickwork is often brought into cubic yards or feet.

Brick walls, which are measured in the above manner, are described in the bill according to the quality of bricks used in the backing up; and if superior bricks are used on one or both faces, the whole face is measured again, and described as "extra to malm (or other) facing." If a wall is built with a sloping or "battered" face, or is circular on plan, the face is measured separately from the solid walling, by the superficial foot.

Where old buildings have to be altered, and part of the walls taken down and rebuilt, the old materials being used up again, measure the walls by the rod "reduced" as above described, and enter them in the bill as so many rods and feet reduced, taking down, cleaning, and stacking old brickwork.

Fence walls are measured in the mode above described, but are usually kept separate in the bill if the joints are struck on one or both sides; but if pointed they may be taken with the other walls, and the pointing measured separately.

The building of ovens and setting coppers is measured by the foot cube, and the ash-holes deducted.

Underpinning old walls with new brickwork in cement is taken separately from the other work, and measured by the rod, as above described: unless the quantity is small, in which case it is usually charged in a day account, the time or labour and the materials being taken separately.

In measuring brick-nogged partitions take the height by the length, and bring it into superficial yards; deduct the area of all openings, but make no deduction for the timbers built in with the brickwork.

When a layer of asphalte, two courses of slates in cement, or any other kind of expedient is adopted for preventing the damp from rising in the walls, measure the length of the wall by the thickness, and bring it into superficial feet, describing the material employed.

Arches for cellars or vaults, and trimmer arches to carry the hearths of fire-places are measured by the superficial foot, taking the length by the girt upon the curve or soffit, and describing the thickness, and whether in mortar or cement.

Gauged arches, as described in Lesson IX. of "Building Construction," are measured on the face and soffit by the foot superficial; thus, in the flat arch shown at Fig. 63,* take the half sum of the lengths K L and F G, or the length between the skewbacks at half the height, by the depth A I; then take the length F G of the soffit by the width of the reveal, or distance from the face of the wall to the window-frame. In the curved arch of Fig. 65 take the girt of the curve half-way between E and D, from one skewback to the other, by the depth E D; then measure the soffit as before, the length by the width.

Pointing the joints of brickwork is measured by the superficial foot, taking the height of the wall by the width, and deducting openings, making proper allowance for pointing to reveals and soffits of openings. In bringing into bill the pointing is described either as flat-joint, tuck, or otherwise; and when old work has to be pointed the erection of scaffolding and raking out the joints must be added to the description.

Brick or tile paving is taken by the yard superficial, and described as brick-flat, brick-on-edge, in stocks, malms, clinkers, ½-inch or 1-inch tiles, etc.; and the mode of laying is also stated, whether in sand, dry or grouted, on concrete, or otherwise.

Brick-on-edge coping to fence walls is measured in with the wall when in mortar; but if laid in cement, or if a different kind of brick is used, its length is taken separately, as well as being measured with the solid brickwork, and is entered as extra to brick-on-edge in cement.

Measure all drains by the foot-run, describing the size and quality, and whether glazed-ware, socket-pipes, or built with bricks and tiles. Number all bends, junctions, traps, cesspools, etc., describing the sizes. Where large drains or sewers have to be measured they can be taken by the foot superficial, as described for arches, or the brickwork by the foot cube.

Measure by the foot-run all narrow cuttings to brickwork, such as chases, bird's-mouths, groins of arches, narrow splays, chamfers, beads, quirks, rounded corners, string courses, cornices, tile-creasing, filleting, cutting and pinning edges of landings, etc. But all splays and chases more than four inches wide are measured by the foot superficial.

Number all items which cannot be measured, as bedding and pointing sash and door frames, cutting and pinning ends of steps, inserting air-bricks, fixing chimney-pots, coring flues, setting stoves and chimney-pieces, etc.

Where iron hooping is used as a bond in brickwork its length is to be taken in yards, the width and thickness being described. Iron chimney bars are taken in the same manner.

FORTIFICATION.—VII.

BY AN OFFICER OF THE ROYAL ENGINEERS.

OBSTACLES.

General Remarks on their Application.—In every scheme of defence it is evident that a great effort must be made to render the enemy's advance as difficult and slow as possible.

The means employed for this purpose will, of course, depend upon the nature of the country, and on the sort of troops against which the war is being carried on. They may, however, be classified under two general heads.

1st. Those works (generally of destruction) which are intended simply to increase the difficulty, and cause delay in the enemy's march; but which are not necessarily within range of the points chosen for defence.

2nd. The appliances and arrangements usually available for the formation of obstacles which are not, perhaps, formidable in themselves, but yet answer their purpose in checking an enemy's advance, and forcing him to work at removing or destroying them while actually under the fire of the defenders.

When time admits of it there can be no doubt that the latter kinds of obstacles should invariably be employed to supplement the slight defensive powers of ordinary field-works, and, indeed, should be used in any part of a position where an offensive return or counter-attack on the part of the defenders is not intended.

The former class of obstacle includes every species of work that the inhabitants of an invaded territory can devise to hinder the advance of the invaders; and if thoroughly carried out, necessarily involves so considerable a loss of property that they should not be undertaken without carefully ascertaining that the results are likely to be commensurate with the cost.

There is no doubt that if a population is sternly determined to sacrifice and destroy everything, and utterly ruin themselves, rather than allow the invasion to succeed, they can in all countries greatly increase the difficulties of the enemy, and in some climates may render his success impossible. In 1812 the burning and destruction of everything that would shelter the enemy from the severities of the winter enabled the Russians to repel their otherwise invincible foes. It must be remembered, however, that in more populated countries it would be almost impossible to carry out such a means of defence as that referred to. The strong patriotic feeling of the people would probably prompt them to endeavour to obstruct, and hinder the march of the enemy's troops; but no really important results can be obtained unless the peasants are prepared to act in concert on some large and previously determined plan, and are, moreover, ready to follow up their acts by others much more difficult to execute, such as the total abandonment of the district by the whole able-bodied population. This would throw the labour of overcoming the obstacles on the invaders themselves, and would probably check the advance considerably.

What more usually happens, however, is that numbers of the inhabitants remain to look after their property, and consequently are seized and forced to supply the extra labour required to enable the enemy's advanced guards to clear the way for the mass of their troops. Nothing, therefore, can be more senseless than for the inhabitants to fell the trees and block up the roads, if they remain on the spot, and have within a few hours to remove the obstacles they themselves created; unless from the enclosed nature of the country the enemy is necessarily restricted to these roads for his guns, wagons, etc., in which case every delay, however small, would be of use. Any action of this kind by the unarmed population, unless it is so carried out as to materially assist the cause of their own army, is to be deprecated, as it can only result in harsh treatment by the invaders, and (as was so often proved in the late war in France) rarely has the effect of making the heads of the enemy's columns halt or even check their advance. This was doubtless due in a great measure to the open nature of the country, which admitted of obstacles being easily turned or avoided, and also to the fact that in all modern armies the advanced guards are supplied with the means of bridging rivers, and clearing away such hindrances as are likely to be met with; moreover, they march so far in advance that any slight check or difficulties they have to encounter are probably overcome before the main force arrives. In many parts of England the fences are so numerous and large that an enemy would be obliged to keep to the roads with his guns and cavalry, and in these places the passive obstructions that could be so readily made by ordinary farm labourers, such as felled timber, barricades of carts, etc., would be invaluable, provided they were carried out intelligently under the direction of engineer or staff officers, who, realising that the enemy will advance by many roads at once, would take care that labour was not wasted on obstructions that could be easily avoided.

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* For this and Fig. 65, see TECHNICAL EDUCATOR, Vol. I., pp. 263, 264.

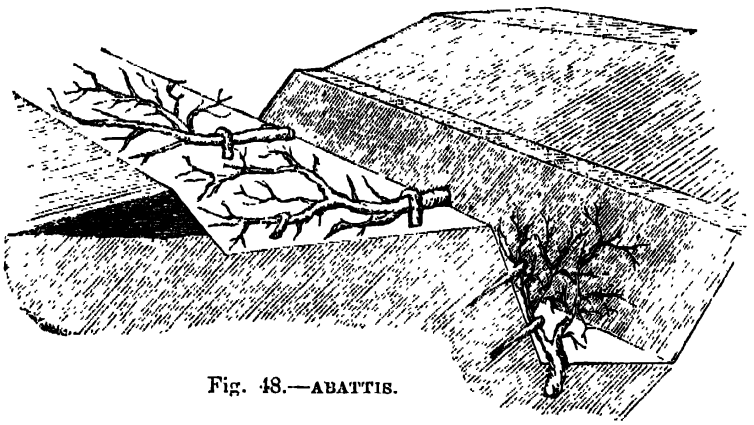


Fig. 48.—ABATTIS.

The most important of this class of obstacles are the destruction of railway tunnels, bridges, dykes, canal banks, etc. Their destruction, however, is often a severe national loss, which is felt long after the war is at an end, and therefore the instinct to destroy everything that may be of use to the enemy should not be blindly indulged in. There are, of course, cases when the safety of a retreating army, and possibly the fate of a nation, may depend on the timely destruction of some great bridge or other public work, by which the delay of even a few hours is occasioned.

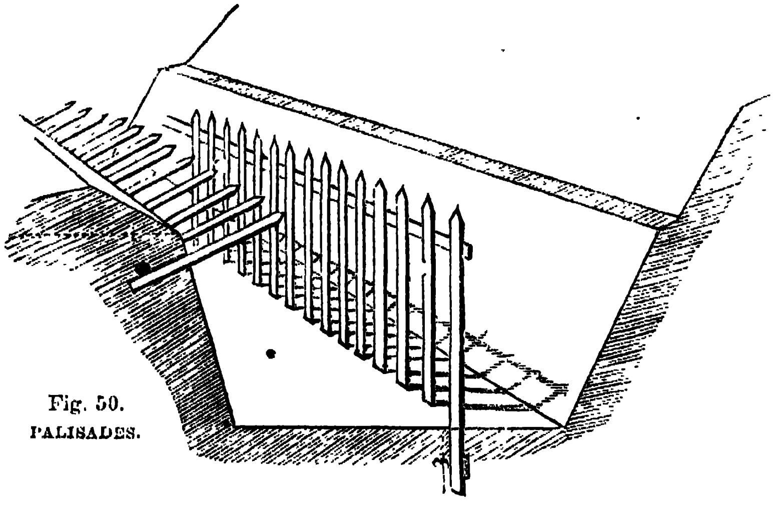


Fig. 50. PALISADES.

[illegible] of bridging is unopposed, a military bridge can usually be thrown across any ordinary river in about three-quarters of an hour, and that consequently the destruction of a great national work may really only result in delaying the enemy's march by that length of time. When a railway viaduct is destroyed under those circumstances the inconvenience to the enemy will be far more serious, as a temporary wooden bridge to bear railway traffic must needs be a large undertaking, especially if care has been taken in the demolition of the piers to leave no solid basis remaining from which to support the new bridge.

Obstruction to Railways, etc.—In selecting a railway tunnel for demolition, one should be chosen at some point on a main line where, from the nature of the country, it will be a work of great difficulty to divert the railway and carry it round or over the range of hills through which the tunnel is bored. A case of this kind, that gave much trouble to the German troops, was a tunnel on the Paris and Strasburg line, about thirty miles east of Paris, which was found so difficult to repair that a loop line had to be constructed to avoid it. Railways may be temporarily obstructed in time of war by small parties of men, who should collect the rails and sleepers, and having formed a fire with the latter, the rails should be heated until they are capable of being bent and twisted, so as to prevent their being used again. The destruction of the water-tanks, turn-tables, and other accessories of a railway-station, could be readily and rapidly executed by men accustomed to their uses. The question of the repair and demolition of railway lines in time of war is, however, too large a subject to be dealt with here.

An army retiring through an enemy's country would probably resort to the use of this more serious class of obstacles, both because it would be reckless of the damage done to the national property of their adversaries, and also because any of the slighter kind of obstacles would be promptly removed by the population to facilitate the advance of their own troops; whereas, exactly the reverse of this policy would be adopted as soon as the retreat had to be conducted through its own territory.

Inundations.—Small streams, rivers, etc., may be converted into a most valuable passive defence by forming embankments or dams across the valleys of such a height as to cause the water to rise and inundate a considerable extent of country. An inundation is only really a serious obstacle when it is not fordable, *i.e.* where the water at its shallowest part is at least six feet deep. This, however, is not often practicable, as it would in most cases involve the construction of dams too large and too solid to be hastily built. A shallow inundation may, however, be rendered very difficult to cross, by digging deep trenches, pits, etc., at intervals across the probable line of the enemy's advance, and causing the water to rise just so high as to hide these from view.

The length of valley inundated will depend upon the height of the dams and on the slope of the water-course of the valley itself; the breadth of the inundation on the height and length of the dam and the slopes of the sides of the valley.

A contoured survey or levels must have been taken before the exact size of the dams and extent of inundation can be determined; and as the inundation is only an obstacle so long as the dams are in good order, it follows that their position should be such that they can be seen and defended by the fire of troops placed on the near side of them.

As regards the materials to be employed, no data can be given, except that the side of the embankment that has to retain the water must be faced with clay well puddled or mixed, and that the thickness of the bank at top, if constructed of earth, should at least be equal to the depth of water, the slopes being on the side next the water $\frac{1}{2}$, and $\frac{1}{3}$ on the other side (Fig. 47).

As in the course of time the water would gradually rise and flow over the embankment, and would thereby certainly destroy it, sluice-gates are a necessity for every dam, in order that the level and action of the water may be controlled.

Of the class of obstacles used to delay the enemy while under fire, the following are those most generally employed:—Abattis, entanglements, pointed stakes, trous de loup, palisades, fraises, fougasses, chevaux de frises, crow's feet.

In their application the following principles should be borne in mind—viz., that they should be so placed as to be hidden from the enemy's fire, while within view and range of your own works; they should be so solidly constructed as to cause a serious check to the attacking troops, and should give no cover to them when they are engaged in breaking through the obstruction.

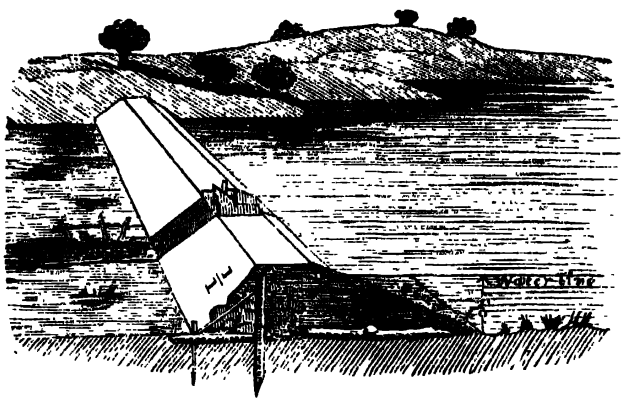


Fig. 47.—AN EMBANKMENT.

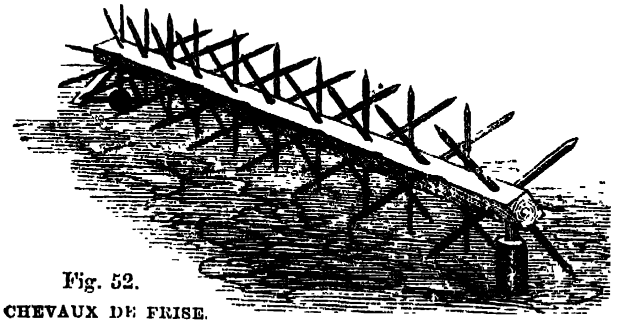


Fig. 52. CHEVAUX DE FRISE.

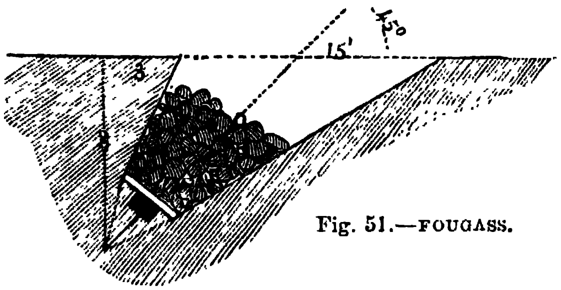


Fig. 51.—FOUGASS.

Abattis.—Abattis consists of a number of trees or large branches placed in a row on the ground, with the boughs (which are pointed) directed towards the enemy. Where the trees are growing on the spot required for the abattis, an admirable obstacle can be readily made, as the trunks should be only sufficiently cut through to allow of the trees falling over. By this means it will be very difficult for the enemy to remove them, or get through while under fire, as each large tree would be a fixture, and smaller branches should be interlaced with their own, to complete the obstacle. The real difficulty in the employment of abattis is the removal of large trees and branches, from where they are cut down, to the required points. The mode of attacking abattis would be to break a number of large gaps in the line with shells, before the attacking columns came up; and for this reason, when used in the defence of field-works, abattis should be placed either upright in the ditch at the foot of the counterscarp, or else in front of the ditch, but protected from view of the enemy by a raised glacis (Fig. 48).

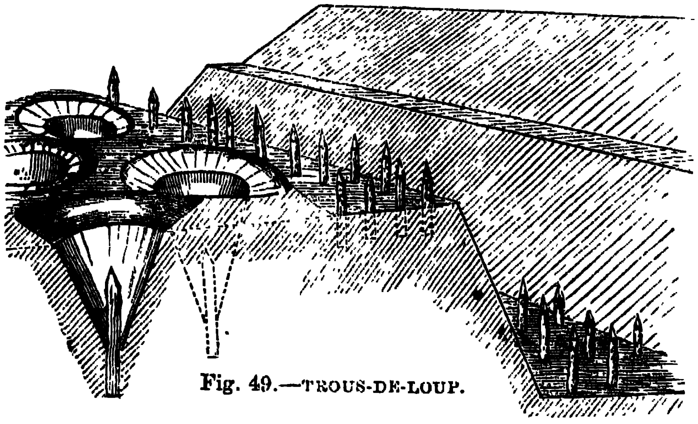


Fig. 49.—TROUS-DE-LOUP.

Entanglements.—An entanglement is in many instances a useful obstacle, and requires no great skill to construct. It may easily be made by driving a number of rows of stout pickets in front of a work, and connecting them together with strong wire, at about two feet from the ground, so as to prevent the possibility of a rush forward on the part of the attacking columns, until the wires have been cut. This would be a troublesome operation under fire, and one which is not satisfactorily performed by the action of shells, the effect of which is often to twist and bend the wire, forming a more difficult entanglement than before. Thick brushwood and coppice may be formed into an entanglement by cutting the stems half through, and bending them down, the ends being buried or pegged to the ground. A series of rough hoops are thus formed, which are difficult to get over by a body of men moving rapidly forward, and who are, moreover, under fire while so doing.

Pointed Stakes.—Rows of stout pickets driven about three feet into the ground, and their ends subsequently pointed, may be employed with advantage to increase the difficulty of attacking a work. If placed in the bottom of a ditch, and near the edge of the counterscarp, they render the task of jumping into the ditch a dangerous one. This class of obstacle was freely used by the Chinese, in the defence of the works the British troops attacked on the Peiho river.

Trous de Loup.—Trous de loup are pits arranged in several rows, and placed chequerwise, so that the interval between each pair is covered by the pit in front. Each pit is furnished with a stout pointed picket, driven into the bottom of the pit. They should either be of such a depth, and so narrow at the bottom, that they cannot be used as rifle-pits by the assailants, or so shallow as to afford no cover. The larger kind are usually conical in shape, ten feet from centre to centre, and six feet deep (Fig. 49).

Palisades.—Palisades are stout palings, the uprights of which are usually half timbers nailed to a couple of longitudinal rails. The uprights should be placed so close, as to render it difficult to get through even by the removal of one of them; and of such a length, that they project ten feet above ground, their butt-ends being buried three feet below the surface. Palisades, therefore, are somewhat like stockades in construction, but, of course, do not give protection from fire, and are used merely as an obstacle, placed usually either in the ditch, or across the gorge of an open work, in which positions they would be screened from view, and possibly from the fire of the enemy. When placed in the ditch, they should be either in the centre, or somewhat nearer the counterscarp side, to be as much protected as possible, and yet not so near that they can be jumped over from the edge of the glacis (Fig. 50).

Fraises.—Fraises are palings similar in construction to palisades, but placed in a nearly horizontal position on the berme, or projecting from the counterscarp of a work, to increase the difficulty of the passage of the ditch. In order that the ribband, or top rail, should not be used as a means of pulling them over bodily into the ditch, it is nailed nearer the butt-end, and is covered by the earth of the parapet or glacis. Fraises on the escarp side are liable to damage by the enemy's fire. Both fraises and palisades are sometimes constructed of wrought iron, and used in connection with permanent fortifications.

Fougasses.—Fougasses are small mines placed close to the surface, and loaded with stones or shells. They are intended to act as a species of mortar, propelling their contents in the direction and at the moment of the attack. In some situations, such as the end of a street in a village where the exact point of attack is known, they may be useful as a means of defence; but, except for their moral effect, it is doubtful if they actually produce many casualties, and, moreover, they can only be used once, and cease to be an obstacle after being fired (Fig. 51).

Chevaux de Frises.—Chevaux de frises are made by fixing a number of spikes, of iron or wood, to a large beam of wood, which is supported at either end. These spikes project in every direction, and are available for closing the opening into a work, or preventing troops from advancing up a street (Fig. 52).

Crow's Feet.—Crow's feet are formed by welding together four iron spikes, about 4 inches long, in such a way, that in whatever position it may be placed, three prongs are on the ground and the fourth upright. They are useful as a means of maiming horses and stopping a cavalry charge. They may also be employed to prevent a ford being used, provided the bed of the stream is hard enough to prevent their being sunk in the mud.

PAPER AND CARDBOARD MAKING.—II.

BY GEORGE TINDALL.

PREPARATION OF MATERIALS.

MATERIALS of all kinds, whether rags, waste, or vegetable substances, require in the first place careful sorting, to free them from impurities, before being used for any but the very coarsest descriptions of paper. This operation is usually performed by women and girls upon a lettice or table, the top of which is formed of an open-meshed wire netting, through which the dust and finer dirt fall, as the materials are turned over; a common knife, generally a piece of the blade of a scythe, is fixed on one side of the table, or at each end if two girls work at one table, for the purpose of opening seams and cutting rags into smaller pieces. If fine or superfine rags are being sorted, they are generally cut ready for boiling during this operation into pieces not more than four inches square, and this is called cutting by hand; but common rags are usually cut by machinery, and when sorted only large pieces of rag are cut. Here all woollens, braid, etc., are carefully cut off, pins, buttons, and other foreign substances are removed, and the rags are dropped into a box in front of the lettice, which is usually divided by partitions so that the qualities of rags may be kept separate. The degree to which this sorting is carried, depends entirely upon the kind of paper for which they are to be used: if for fine writings, the white rags are carefully sorted out, and the cottons separated from the linens; whilst for inferior printings, etc., the rags are all thrown into one box, only the rejected substances being separated. Waste, both cotton and linen, is very variable in quality, some being very clean, and requiring but little sorting, whilst others are often full of impurities of various kinds: splinters of wood, bits of leather, metal, and many other things, prevail in different samples, depending in a great measure on the different processes of manufacture in which the waste is produced; many kinds are full of impurities, so fine that it is useless attempting to get rid of them by sorting, and such substances are separated by a process called "willowing."

Esparto also is usually first sorted on lettices, and the coarse root and other impurities removed: this grass when pulled—for it is not cut—is tied up in small bundles, and these again are tied up with esparto ropes into large bundles or pressed into bales, and secured with hoops or wire, and large stones are often found carefully concealed in the centre of the small bundles. The roots are not used in the manufacture of white papers, but are available for rough browns or for wrappers.

After sorting, rags requiring further cutting are taken to the "chopper," a machine, in its most improved form, consisting of a large revolving disc, on which strong steel knives are fixed, working against a stationary one. The rags are fed into the machine by means of a felt or blanket passing between two rollers, which compress the rags, and deliver them to the fixed knife, when they are cut to pieces by the action of the revolving blades, and thrown out at the back of the machine.

Waste and other substances requiring it are then willowed by passing through the machine of that name, or, as it is more commonly called in the woollen manufacture, the "devil," being used for tearing up old woollen materials into mungo for remanufacture. This consists of a conical cylinder set with teeth about one inch square, and projecting about three inches from the cone. This cylinder is made to revolve at a very rapid rate, usually about 150 revolutions per minute, the teeth on the cylinder working between similar teeth firmly fixed on the outer casing of the machine. The rags or waste are fed in at the small end of the cone, and are torn to pieces between the teeth of the machine as they pass to the wider end, where they are violently expelled in the current produced by the rapid revolution of the cone. By this means the fibres of the rags or waste operated on are loosened or opened, so that the dirt is more easily acted on, and any lumps or knots are at once expelled.

The next operation is that of dusting, which is performed in a strong open meshed wire cage of considerable length. This is made to revolve slowly, and is enclosed in a wooden framework to keep in the dust expelled from the rags. This cage is either made wider at one end than the other, or the centre is fixed lower at one end, so that there is a gradual fall sufficient to send the rags forward, and the dirt, already loosened by the cutting and willowing processes, passes through the interstices of the wires, the rags being thrown from side to side by the revolving motion of the cage, as they traverse it from the upper to the lower end, where they fall out and are removed to the boilers.

Straw is prepared for boiling by cutting it into chaff, and, unless used for fine papers, needs no sorting. Wood is acted on either by reducing it to powder by grinding, or by breaking and crushing it. Several mills have already adopted, or are about to adopt, the latter plan, in which, by means of a powerful "chopper," a knife secured to a heavy cast-iron disc revolving at a high speed, the blocks of wood are cut into slices half an inch thick, and these are afterwards crushed between iron rollers, and turned out in small chips ready for the boiler.

The boiling process is one of the most important in the manufacture of paper, especially from crude vegetable fibres, as unless these are thoroughly reduced, and all the various parts softened, so as to easily crush and break up, it is impossible to bleach them thoroughly or convert them into fine paper. Fine rags are easily treated: it is only necessary to boil them a few hours in a solution of caustic lime, or with the addition of a small quantity of soda ash, in any kind of pan open or closed, and they are ready for the washing engines; but for other substances stronger solutions must be used, and pans specially adapted for the purpose. Two kinds of boilers find most favour in this country, fixed kiers with a vomiting-pipe, and cylindrical or spherical boilers, which are kept slowly revolving during the boiling of the materials. The former is usually an upright cylindrical boiler with a man-hole at the top for feeding in, and also one near the bottom to take away the boiled materials, or the pan may be shallower and open at the top if no pressure is required; in the centre is an open pipe into which the liquor is freely admitted, and a jet of steam from a steam-pipe opening into this, forces the boiling liquor with great violence up the pipe, over which is placed an iron umbrella, which distributes it over the whole of the pan, thus keeping the boiling mass in a state of constant agitation, and bringing every portion of the contents of the pan under the action of the caustic liquor. The kier is usually made slightly spherical at the bottom, and, if used under pressure, at the top also; it is furnished with a false bottom of perforated plates, through which the sand and other impurities left in the materials escape during the boiling process. The revolving boiler is generally cylindrical, but a spherical one has been introduced; it is mounted on strong metal standards, and made to revolve slowly, a steam-pipe being introduced into one axis for the purpose of boiling. Only one man-hole is required, as the boiler can be filled while this is at the top, and emptied when it is at the bottom into a box placed underneath it. The motion of the boiler, as it slowly revolves, continually throws the contents from side to side, and this is generally assisted by plates running across the length of the boiler, and placed at an angle to the sides, so that every portion of the materials is equally acted on during boiling.

Esparto, straw, and wood require boiling for several hours in a strong solution of caustic soda, the two last-named substances under very considerable pressure; in some mills, where rags and waste are also used, the liquor, after use for any of these substances, is pumped into a cistern, and used over again with the addition of a little caustic lime for the boiling of rags. Caustic soda may be procured already prepared and solidified in drums of iron, and when used in this state the drums are cut open and the contents simply added to the material to be boiled, with the addition of a sufficient quantity of water; but most makers prefer using soda ash, and making it caustic before using; this is done in round open pans fitted with an agitator inside, turned by steam or by hand. The soda ash being placed in the pan with water, and heated by means of a jet of steam, sufficient caustic or hydrated lime is placed in a cage inside the pan, and the agitator is set in motion; a strong ebullition is immediately set up, and the lime loses its caustic qualities, which are transferred to the alkali, rendering it a much stronger and more active detergent. After agitating the liquor for some time, it is allowed to stand, and the clear liquor is then run off into a cistern, the impurities settling to the bottom of the pan, and the refuse lime being retained in the cage in which it was placed; the pan is again filled with water, which is also agitated for some time, and after standing is again run off into the cistern, and added to the strong liquor. This may be repeated two or three times with advantage, taking care that the liquor used is of known strength at the time.

The process of boiling is simple. If rags are used, as they are brought from the duster they are fed into the boiler, usually a revolver; the requisite solution of caustic lime or soda, and spent esparto liquor, if used, is added; the man-hole is screwed down, steam is turned into the boiler, which is at the same time set in motion; and after boiling four to six hours, they are emptied into trucks, and sent to be washed. Stronger materials, such as hemp and jute, require a stronger solution; but all these materials described in our first paper as Class *a*, having previously undergone some preparation of this kind, are much more easily and cheaply boiled than the second class. This process is necessary to destroy greasy matter, and to loosen the dirt among the fibres of the material, a great portion of which is carried off during boiling. Esparto is usually boiled in the fixed kier, but sometimes in the revolver, and for this substance a large proportion—in fact, over 20 per cent.—of caustic alkali of ordinary commercial strength, say 48 per cent., must be used, and the boiling continued for eight hours or more before this substance is sufficiently digested: when properly boiled a large handful should be easily twisted to pieces, whilst before boiling three or four blades of this strong grass together defy the efforts of the strongest man to break them. Straw is still more difficult to boil well, on account of the knots which occur so often in the stem: this substance, therefore, is boiled in strong steam boilers under considerable pressure, and sometimes these boilers are fixed in brickwork, and agitators are kept in motion inside to mix up the boiling mass, and prevent any portion of the contents from becoming burnt against the sides of the hot boiler. Wood is also very refractory, and requires a special boiler and very high pressure to reduce it to such a state as to allow of its delicate fibres being got out unbroken. The particles of wood broken up as before described are put into cages, and the boiler filled with these cages: by this means the wood is kept always covered by the boiling liquor, and prevented from floating at the top and becoming charred; after being sufficiently boiled the pieces of wood are so much softened that they may be crushed up between the finger and thumb like so much tinder.

After the materials have been boiled a sufficient length of time, the liquor, if a strong one has been used, is run off, and either pumped into a cistern to be used for rags or for evaporation, or allowed to run to waste, and if possible a copious stream of water is allowed to run through the materials, especially esparto or straw, for the purpose of washing away the gummy and resinous matters which adhere to crude fibres after boiling. The materials are then thrown into wood and iron boxes on wheels, and sent down to the washing engines.

Waste papers, after being dusted in the usual way, are boiled in strong caustic soda in a washing or poaching engine, such as will be described in our next paper, covered with a lid, and with a rolling motion, so that during this process the papers are broken up and partly reduced to pulp, whilst the ink is discharged, and carried away at the same time. This class of waste can, however, only be used for a very inferior class of printings. Clean paper cuttings are best boiled in water only, in an open pan, and stirred with a rod until they are thoroughly softened; they may then be used with other materials for the finer papers.

In boiling at low pressures the exhausted steam from the various engines in the mill is generally used, and this is often collected into a single pipe and conveyed to the boilers. This method may be economical where engines sufficiently powerful are employed; but it must be remembered that this back pressure has to be overcome by each engine in addition to its own work, and other more important processes may be impeded by this extra strain put upon their driving power.

From what has been said above it will be seen that the boiling of vegetable fibres is by far more costly than that of rags and waste. For the latter materials a small quantity of lime at 13s. a ton suffices; while for the former a considerable quantity of soda ash, worth £8 a ton, is required; and it must be remembered also that the waste of crude fibres under this treatment is at least twice as much as that of rags, etc. After this stage, the working of both classes of materials is nearly the same, so that it is here the comparative values of materials to the paper-maker must be tested, in order to decide what is best to be used for a given paper. So long as esparto could be bought at £5 to £6 a ton, it competed favourably with rags at £13 a ton; but when, as was the case a very short time since, esparto advanced to £10 a ton, and the same class of rags to £16 a ton, then their relative values changed considerably, and an enormous impetus was given to the use of straw and wood.

The great cost of soda ash used in this process, added to the pressure brought to bear by landowners on streams, where the deleterious effects of the spent esparto liquor in destroying the fish were severely felt, has induced many paper-makers to recover the soda ash after use by evaporating the liquor, and calcining the residue; and as this can be done with great saving to the maker, it will doubtless become the general practice. The liquor, as it leaves the boiling pans, is pumped up into tanks, and there evaporated, until it becomes of the consistency of treacle: it is then passed into a series of shallow tanks built in brickwork, which with flues passing between them constitute a furnace, heated by means of a coal fire at the bottom: as the liquor becomes thicker it is pushed down into a tank at a lower level, and so on, gradually losing its water, until in the bottom pan it becomes almost solid, and is then pushed forward into the fire and burnt, assisting by its own heat in the evaporation of the remaining liquor; the ashes are then carried away and thrown in a heap, and this is left for some days to burn itself out, soda ash of a comparatively pure character being the result, except in the outer portion of the heap, which has been subjected to the action of the atmosphere and is blackened; this is removed and thrown away.

The restrictions imposed by the Pollution of Streams Act have prevented many makers, especially in the south of England, from using crude fibres, in consequence of the poisonous effects of the spent alkali; whilst in Lancashire and the north of England, where the streams are already fouled by other manufacturing operations, these fibres are extensively used, and paper-making in this part of the country has thereby received such an impetus as renders it likely to soon eclipse the county of Kent, the cradle of paper-making, and its southern neighbours, if it does not already do so. This only at present applies to the quantity of paper made, not to the quality.

THE LATHE.—III.

By Henry Northcott.

MODIFICATIONS OF THE LATHE FOR SPECIAL PURPOSES—BACK GEARING FOR CUTTING METAL.

The ground we have traversed has thus far been common to all classes of turning, but from this point improvements in the lathe have divided themselves into several main classes, depending upon the style of work the lathe has been designed more especially to perform. Thus the mechanical engineer has increased the power of the lathe, so as to enable work of considerable magnitude to be turned as easily as the smallest wire in the simple lathe; he has adapted mechanism so that the lathe may be driven by the powerful force of steam; he has increased its accuracy by rendering accuracy no longer entirely dependent upon the operator's skill; he has gradually added to it mechanism by which the action of the lathe is rendered automatic; and he has rendered it capable of producing not only circular work, but such irregularly-shaped articles as gun-stocks, shoe-lasts, and others; and he has adapted it to a multitude of uses, suggested to him by the great variety of forms he is continually called upon to produce.

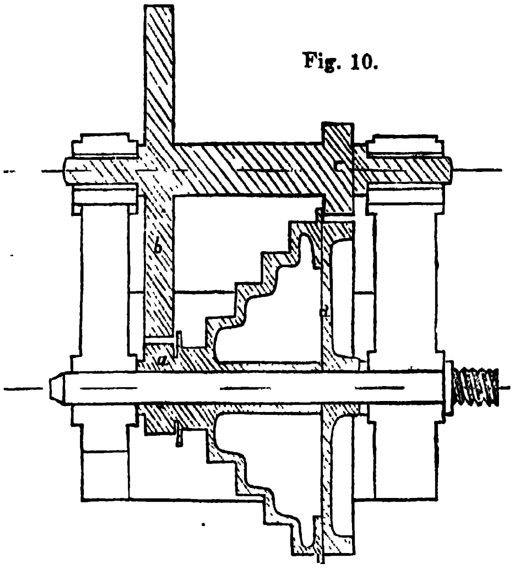


Fig. 10.

The amateur mechanic also, whilst using to some extent the means devised by the engineer for obtaining power, accuracy, and the power of self-moving, has contrived to increase the powers of the lathe by the addition of mechanism for planing, for cutting the teeth of wheels, for drilling holes, and various other operations, each of which usually requires a separate machine, but which on a small scale are quite readily and satisfactorily managed in the lathe.

The ornamental turner, on his part, has in another direction added immensely to the powers, and also to the complexity, of the lathe. He has added various instruments called chucks, some to vary the position of his work, some to produce non-circular sections, and others to produce all kinds of beautiful curves and ornamental figures, some of which are singularly graceful, and some far too intricate for the eye to follow unassisted by the microscope. The ornamental turner has also added means for the exact division and arrangement of his work, various cutting instruments for the production of ornamental solids and carved work, apparatus for cutting medallions, and various other mechanism. All these improvements and additions have made the lathe certainly one of the most useful machines known to man, and it would be as easy and as short a task to enumerate what cannot be done in the lathe as to say what can. And so far from its work being necessarily of a circular section, I have succeeded in producing by *continuous rotation*, in the same way as for a cylinder, and of any required length, articles whose sections are perfectly square.

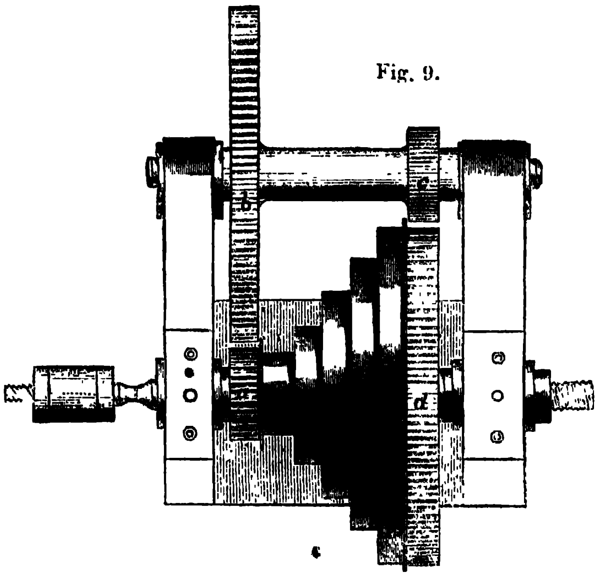


Fig. 9.

The space at my disposal is too limited to allow of my describing the whole of the various modifications of the lathe; but I shall endeavour, by describing a few of the most important and most characteristic, to convey some notion of its extended usefulness.

The greater power is obtained for cutting large pieces of metal by the addition to the lathe of the back gearing shown in Fig. 9. This gearing consists of two pairs of spur-wheels and pinions; one pinion, *a*, being attached to the usual lathe-pulley; a wheel, *b*, and pinion, *c*, being fastened upon a short shaft or axis placed behind the lathe-spindle; whilst the remaining wheel, *d*, is keyed upon the lathe-spindle. In this arrangement of gearing, the pulley is not keyed directly upon the lathe-spindle, but may rotate freely upon it, without drawing round the spindle; or it may be made to rotate the spindle also by connecting it to the wheel *d*. The shaft carrying the wheel and pinion may be drawn towards the lathe-spindle, so as to cause the teeth of the several wheels to gear or engage with each other; or the shaft may be removed outwards until the wheel-teeth become disengaged and capable of independent rotation. When ordinary light turning is being practised, the shaft carrying the back wheel and pinion is withdrawn, so that these wheels then remain idle, and the pulley being connected to the wheel *d*, by means of a small sliding bolt and nut at the side, the lathe-spindle is rotated in the ordinary manner, and at the ordinary speed. But when heavier work has to be performed, and greater power is required, the back shaft is brought in until the several wheels gear with each other, and the lathe-pulley is detached from the wheel *d*, to allow of its being rotated independently of the lathe-spindle. Now, on the lathe being set in motion and the lathe-pulley rotated, the pinion *a*, attached to the pulley, drives the wheel *b*, the back shaft or axle, and the pinion *c*, which latter in its turn gives motion to the wheel *d*, attached to the lathe-spindle, and so to the lathe-spindle itself, and any work attached to it.

The sectional illustration of this double gearing we have given in Fig. 10, in which the same letters are used, will best enable the reader to understand the arrangement and its mode of working; but it must be clearly understood that, whilst the large wheel *d* is always keyed fast upon the lathe-spindle, the pulley and pinion *a* may be connected to or disconnected from the lathe-spindle at pleasure. Disconnected from the spindle when the double gearing in use, the pulley runs freely upon the spindle, driving the latter not direct, but through the other wheels at a much slower speed. For example, supposing the pulley to be rotated, say, 900 times per minute, the pinion *a* to have 20 teeth, the wheel *b* to have 60 teeth, the pinion *c* 20 teeth, and the wheel *d* 60 teeth, if the pulley were connected to the wheel *d*, the latter and the lathe-spindle would necessarily rotate the same number of times as the lathe-pulley itself, or 900 times per minute; but with the double gearing in action, the pulley and pinion *a* would drive the wheel *b* at a speed the inverse ratio of the sizes of the wheels, or 60 : 900 : : 20 : 300, and the speed of the wheel *d* and the lathe-spindle would be 600 : 300 : : 20 : 100. The pulley therefore, in rotating 900 times, would drive the back axis around 300 times, and the lathe-spindle 100 times; and, disregarding friction, whilst the speed of the lathe has been *decreased* nine times, its power of overcoming resistance has been *increased* to precisely the same extent. Or in other words, by the use of this gearing we can take a cut nine times as heavy, or one that opposes nine times the resistance to the lathe's rotation. The value of this addition to the lathe is now very apparent, but besides the increase in power, the decrease of speed is very frequently desirable of itself, as all materials can best be turned when rotating at a certain speed; and even with wood, when this speed is very much exceeded, the tools are spoiled by the excessive heat that is developed by the friction.

TECHNICAL DRAWING.—L.

GOTHIC STONEWORK.

GOTHIC ARCHES.

THE principles of the general construction of arches having been given in the series of papers which have already appeared on "Building Construction," it will only here be necessary to describe the characteristic forms of those associated with that period of architecture which forms the subject of our present study.

It has been said that the semi-circular arch (Fig. 433) is characteristic of the Norman period. Although, however, it is certain that generally the Norman arches were of this form, it is equally certain that they were not so universally. A form is frequently found in which the spring of the arch does not take place from the *abacus* or upper member of the capital, but at some distance above it. An arch of this kind is said to be stilted (Fig. 434).

There can be no doubt that this form of arch was not so much a matter of taste as of necessity. It is evident that the arches were stilted to admit of constructing the vaulted roof according to the simple method then known; one essential feature of which required the four arches of the vault to be of the same height. Stilted arches sometimes approach the *horseshoe* form (Fig. 435), in which the centre is above the springing. It is probable, however, that this form is seldom intentional, but the result of imperfect construction.

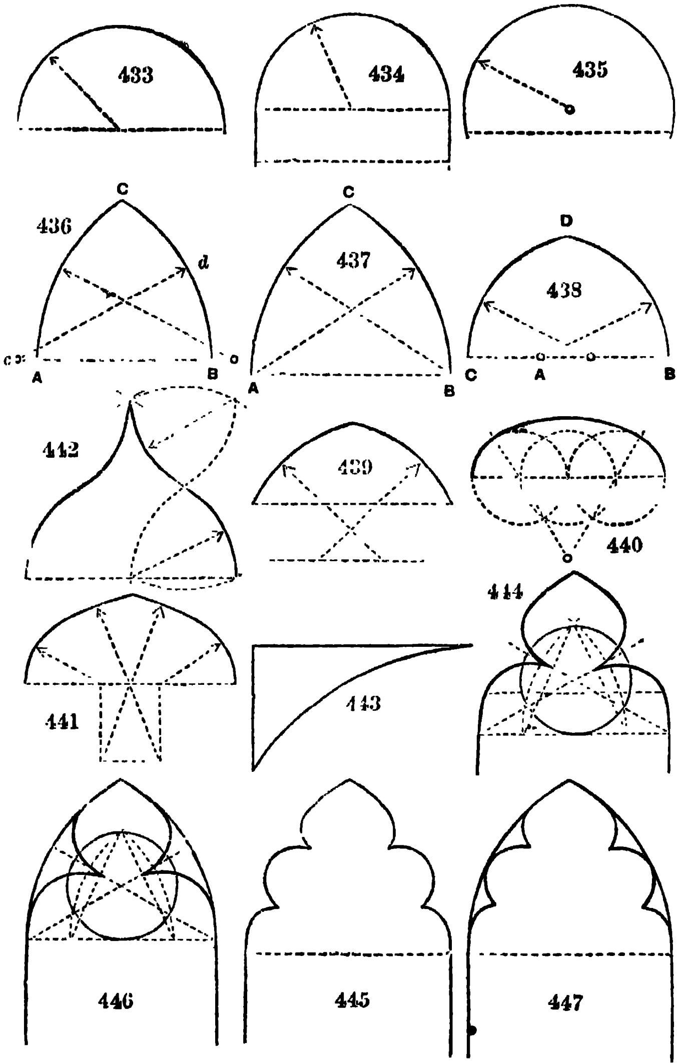
Pointed arches are either—

1. The *lancet arch* (Fig. 436), described about an acute-angled triangle, A B C, the radius (*c d*) being longer than the width of the arch (A B).

2. The *equilateral arch* (Fig. 437), described from two centres (A, B), which form the extremities of the span of the arch, which is thus described about an equilateral triangle, A B C.

3. The *drop arch* (Fig. 438), which has a radius (A B) shorter than the span of the arch, and is thus described about an obtuse-angled triangle (C B D).

All these pointed arches may be of the nature of segmental arches (Fig. 439); that is, having their centres below their springing, as shown in the figure.



Figs. 433-447.—VARIOUS FORMS OF ARCHES.

Mixed arches consist of—

1. The *three-centre* (Fig. 440), which may be called semi-elliptical, since they are constructed on the principle used in drawing the ellipse (or rather the figure approximating to it, since no portion of a true ellipse is really a part of a circle). This method has been shown in lessons on "Practical Geometry applied to Linear Drawing," and its adaptation in the present instance will be seen from the figure.

2. The *four-centred*, or *Tudor arch* (Fig. 441), which has two of its centres in or near the spring, and the two others far below it.

3. The *ogee*, or contrasted arch (Fig. 442), which may be taken as characteristic of the Decorated period. This form of arch has four centres; two in or near the spring, and two above it and reversed.

It has been usual to connect the pointed or lancet arch as the characteristic feature of the Early English period. Mr. Rickman has, however, shown that this is far from being the case; and that whilst every form of arch, with one exception, is found in Early English buildings, so the lancet arch is found in both the succeeding styles; the single exception referred to being the four-centred, or Tudor arch (Fig. 441), which is the peculiar property of the Perpendicular style.

It is, however, true that the lancet arch is the form that most commonly occurs in the windows of this period, and almost every Early English building presents examples of either single, double, or triple lancets. But however frequently this form may have been chosen as the favourite arch for windows, it is certain that a much wider range was allowed for doorways, pier-arches, and arcades; it is not uncommon even to meet with instances of the semi-circular arch in doorways of undoubted Early English date.

The space included between the arch and a rectangle formed at the outside of it, is called a *spandril* (Fig. 443). This is often filled with characteristic ornamentation, which will be described in due course.

We must now speak of another class of arches, the introduction of which is generally referred to the Early English period—viz., *foiled* and *foliated* arches.

A *foiled* arch is formed by uniting three or more small arches together, each springing from the adjacent ones, the result being called a trefoiled, cinque-foiled, etc., according as three, five, or more arches are united in its formation. Thus Fig. 444 is a trefoiled arch, and Fig. 445 a cinque-foiled arch.

A *foliated* arch is a foiled arch placed within a simple arch, as in the following two figures. The arch in Fig. 446 is said to be *trefoliated*, and that in Fig. 447 to be *cinque-foliated*.

This distinction was first pointed out by Professor Willis. It is of considerable importance, since it appears that the foiled arch was introduced at an earlier period than the foliated—the latter being a fuller development of the former.

Foiled arches of a very rude description are occasionally found even in late Norman work, and appear to have been introduced either immediately before or simultaneously with the pointed arch; for in a window at Cambridge there may be seen two foiled lights gathered under a semi-circular head. On the Continent this introduction seems to have taken place rather earlier; but in our own country we have very few instances of foiled arches before the commencement of the thirteenth century.

The foliated arch was at first treated as an independent construction; it was formed of separate voussoirs, and had its own subshafts to support them. In such arches the entire foliation might be removed without affecting the arch enclosing it. This independence of the arch and its foliations became less and less frequent as the style advanced, and ultimately the foliations were reduced to mere excrescences, growing, as it were, out of the enclosing arch. It is in this form alone that they are found in the Decorated and Perpendicular styles.

Foliated arches are sometimes called *feathered*. The points where the foliations of arches meet are called *cusps*.

THE NORMAN PERIOD: ITS MASONRY, ARCHES, MOULDINGS, AND ORNAMENTS.

The Norman style is closely allied to the debased Roman examples of the Eastern and Western Empires, and may be considered as a subdivision of the Romanesque.

This style flourished principally and primarily in Normandy, and hence its name. It became, however, prevalent in countries where the Normans obtained influence, and, amongst others, in England.

The exact date of its introduction into this island has been much disputed. Some historians affirm that it was but a development of the previously existing Saxon; others, that it was introduced by Edward the Confessor; whilst a third party maintain that it was brought over by William the Conqueror.

It is, however, certain that the style became fully developed soon after the Conquest, and it may be said to have prevailed from the middle of the eleventh to the latter part of the twelfth century, or to the close of the reign of Henry II. It is styled generally the English style of the twelfth century, and dates from 1066 to 1170; or, if the Transition or semi-Norman be included, to 1200.

"The Conqueror and his countrymen," says Mr. Nicholson, "were great builders, and the monkish chroniclers tell us that after their arrival churches were erected in almost every village, and monasteries were soon to arise in the towns and cities designed in the new style of architecture. From Doomsday Book we learn that the number of churches had increased to such an extent, that at the time of its compilation there were no less than seventeen hundred in existence."

The plans of the larger churches belonging to this period, such as those of cathedrals and other ecclesiastical establishments, are usually cruciform, having a low, massive tower at the intersection of the nave, choir, and transepts, the choir being frequently terminated with a semi-circular apse.

The aisles of the nave are frequently continued at the side of the choir, and round the apse; and in this case the high altar is situated between the easternmost piers, with a screen or reredos at its back stretching between the piers. Thus a space was left here behind the altar which was named the *retro-altar*, and this allowed of processions passing entirely round the church.

In some instances the choir is surrounded with chapels, having likewise apsidal terminations. The aisles were extremely narrow, sometimes not more than from four to six feet in width. The western façades are occasionally flanked by towers, but more frequently by only turrets or buttresses.

The walls of buildings of this period were of immense thickness; but the masonry was not in all cases solid, being composed of two external walls or facings of "ashlar" work (see "Drawing for Stonemasons"), having the intermediate space filled in with grouted rubble, gravel, flints, etc. Sometimes, however, the walls were made up of solid rubble work, with quoins of ashlar. The joints of ashlar in early work are extremely wide, being frequently as much as an inch in thickness. Many walls of the first description have failed from the outward pressure of the core of loose material; and it is not an unfrequent occurrence to see a Norman wall considerably out of the perpendicular. The introduction of buttresses at a later period led to a great improvement in the construction of walls, adding materially to their efficiency and strength, while at the same time it lessened the consumption of material.

The arches built by the first Norman architects were more or less of a semi-circular form, and of a very plain description. When the wall in which they were constructed was only of a moderate thickness, they generally consisted of a single course of stone or "voussoirs," the edges of which were left square; but, as already stated, the walls were generally of very great thickness, and when this was the case two, three, or more courses of voussoirs were employed, each course receding from the face of the ring of masonry by which it was surrounded.

In the early Norman period the bishops and abbots appear for the most part to have possessed considerable skill in architecture. It is said that no less than fifteen out of the twenty-two English cathedrals contain portions which are undoubtedly of Norman workmanship, the older parts of the cathedrals of Canterbury, Durham, Winchester, Gloucester, Peterborough, Ely, Norwich, Lincoln, and Oxford being all built in what is now called the Norman style.

CHEMISTRY OF THE FINE ARTS.—II.

By Professor Church, Royal Agricultural College, Cirencester.

YELLOW PIGMENTS: YELLOW OCHRE, CHROME YELLOW, COBALT YELLOW, CADMIUM YELLOW—RED PIGMENTS: VERMILION, RED LEAD, VENETIAN RED, MADDER AND COCHINEAL REDS—BLUE PIGMENTS: CŒRULEUM, COBALT BLUE, NATIVE AND ARTIFICIAL ULTRAMARINE, INDIGO, PRUSSIAN BLUE—GREEN PIGMENTS: EMERALD GREEN, VERDIGRIS, VIRIDIAN—BROWN AND BLACK PIGMENTS.

Turning our attention to yellow pigments, we may first notice yellow ochre, a permanent but somewhat dull colour, which occurs in nature of several tones and hues, and may be made to yield fresh modifications by heat, chemical treatment, or admixture. This pigment was used by the ancient Greeks, and by the Roman artists, being abundantly found in the remains of mural decorations at Pompeii, and having been observed in similar circumstances at Roman stations in England. When pure it is a combination of rust of iron and water, in chemical language a hydrated peroxide of iron, or ferric hydrate. In 100 parts the proportion of iron peroxide in the darker kinds of ochre approaches 70 parts, but the residue of the mineral is made up of minute proportions of many other ingredients besides water. The water essential to the mineral is sometimes as low as 10 per cent. of its weight, and sometimes as high as 30. Those kinds of yellow ochre which are of the desired colour, but contain as little water as possible, are the most suitable for use as pigments. This proportion of water may be at once ascertained, with sufficient accuracy, by heating 100 grains or less of the sample in a porcelain basin over a spirit-lamp, and noting what loss of weight the ochre thus sustains. When the ochre has been mixed artificially with other substances, such as chalk or china-clay, of course this experiment alone is not of much use. And it must be noted that many natural ochres do contain calcium carbonate (carbonate of lime) or aluminium silicate. These substances may be recognised by heating the ochre with a little strong hydrochloric acid: if complete solution be effected with effervescence, the first named substance is present; if a white and gelatinous residue be observed after boiling, then some substance similar to clay is contained in the ochre. Ochre may be reduced in tone by the admixture of any white pigment; or it may be rendered darker and more red in hue by roasting, or by treatment with a weak acid such as vinegar, or by the use of these two last processes in succession.

Chrome yellows are of different tones, ranging from a pale yellow, like that of sulphur, up to a deep orange-red. Of the paler chrome yellows the best is the barium chromate, which sometimes goes under the names of yellow ultramarine and lemon-yellow, a term which is also applied to a lead chromate mixed with lead carbonate and sulphate. The barium chromate is made by precipitating barium chloride with potassium chromate or bichromate. Solutions may be used or the two salts may be finely ground, and then water added in small quantities and the grinding continued. This barium chromate may be washed free from soluble salts, and forms a beautiful yellow pigment (as does also zinc chromate), not liable to change, like the common chrome yellows, which latter are compounds of lead, and therefore capable of being blackened, like white lead, by the action of sulphuretted hydrogen. However, from the brilliancy and purity of the yellow and orange colours afforded by the lead chromates, they are extensively used in the arts, as pigments and as dyes. The commoner chrome yellows are made by treating 4 parts of lead sulphate or chloride with 1 part of red potassium chromate, but the finer preparations are obtained by precipitating the lead acetate in solution. Clay, plaster of Paris, chalk, and many other white substances, are used to an immense extent in adulterating chrome yellow, but the pure substance will be found to dissolve completely and without effervescence, when boiled in dilute nitric acid. Though acted upon by alkalies, and by sulphur compounds, the chromes are not affected by these agents to any appreciable extent when used in oil-painting, especially if they have been properly prepared in a dense condition, and are not used as freshly-made precipitates. A statement has been made that "if an oil picture painted with chromes be washed with an alkaline soap, it is quite certain that some of the chromates will be dissolved up." This statement has been found to be directly contradicted by experiment, and it is, therefore, incorrect to condemn the chromes on this score. The most permanent lead chromates are those of an orange or red colour; they contain a larger proportion of lead than the paler sorts. A fine chrome red may be made by projecting 1 part of dry yellow lead chromate into 5 parts of fused nitre. The fluid mass is poured out, broken up, ground, and washed thoroughly with water. More economical plans depend upon the action of alkalies or powdered litharge, in the presence of water, upon the common yellow chrome. By modifying the temperature, strength of solution, and duration of the operation, any tint of orange or orange-red may be thus obtained.

Cobalt yellow or aureolin is of comparatively recent introduction, and was, indeed, only discovered in 1852. It contains cobalt, potassium, and some oxide of nitrogen, and is often spoken of as a nitrite of the two metals just named. When prepared by the addition of acetic acid and potassium nitrite to a solution of cobalt nitrate, and then keeping the mixture in a warm place for some time, it does not assume its best characteristics as a pigment. When, however, nitric oxide gas is passed into a solution of cobalt nitrate, to which an amount of potash has been added just sufficient to make it slightly alkaline, the product is of good quality. Or potassium nitrite and cobalt nitrate, both in powder, may be heated with a little acetic or nitric acid. Although common aureolin, or cobalt yellow, is blackened by hydrogen sulphide and somewhat acted upon by alkalies, it may be safely used, when of proper density, both in water-colour and oil painting without fear of change. The only pigment which it appears to injure, at all events in oil-painting, is indigo, which then gradually loses its colour, perhaps owing to a reducing action of the aureolin, the substance known to chemists as white or reduced indigo being formed.

Orpiment, or King's yellow, is a beautiful but dangerous pigment: it was employed in ancient art though rarely; its Latin name, *auripigmentum*, or golden paint, is seen in a contracted form in the word *orpiment*. This substance is a compound of arsenic and sulphur, which occurs in nature as a mineral, and may be made artificially. As it is made, or may be made, by the action of sulphuretted hydrogen, that gas does not change its colour, but it is itself liable to change the colour of white lead and some other pigments. King's yellow when pure is perfectly volatile on heating it on a piece of porcelain, and does not become paler or darker when warmed with dilute hydrochloric acid.

Cadmium yellow is the sulphide of the metal, and possesses a most intense orange-yellow colour. Though sold at a high price, the metal cadmium is not really so costly as to prevent this splendid and permanent pigment from being much more largely employed than at present. It must be prepared and washed with great care if it is to be used with white lead, and there seems to be some reason to fear that even then the sulphur in this compound is capable of effecting changes in lead pigments with which it may be mixed. By varying the temperature and strength of the cadmium chloride solution used in preparing this colour, or by making it in the dry way with a cadmium salt and an alkaline sulphide, or with cadmium oxide and sulphur, its tint may be varied from a rich yellow to an orange-red.

Other mineral yellows are of less importance: among them are certain lead oxychlorides and oxysulphates; a basic lead antimoniate called Naples yellow; and also lead arseniate and iodide.

But two yellows of organic origin must not be omitted here, since both of them are useful colours in water-colour painting. *Purree* or Indian yellow is the magnesium salt of a curious acid called the euxanthic. Its colour may be greatly improved by dissolving the crude Indian yellow of commerce in boiling dilute hydrochloric acid, after having washed it with hot water, filtering the solution, and adding a little ammonia to the hot liquid. The yellow crystalline powder which will be found deposited from the liquid when it has remained twenty-four hours, will prove on grinding to have a richer colour than the original *purree*. Gamboge is a rich yellow pigment belonging to the gum-resins. Its essential constituent is a brightly coloured yellow resin, which when in films has a hyacinth-red colour, and is insoluble in water, but soluble in spirits of wine and in alkalies. Good gamboge contains 70 per cent. of this ingredient. The pipe gamboge of Siam is the best kind.

Amongst red pigments we may first notice vermilion, although it is by no means a perfectly satisfactory pigment. Vermilion is the red variety of mercuric sulphide, and occurs naturally as the mineral cinnabar. It may be made artificially by subliming the black amorphous sulphide of mercury, which thereby undergoes a molecular, not a chemical change, and becomes crystalline and red; or it may be made by grinding sulphur and mercury or its oxide together for a long while, and then warming the mixture in the presence of some caustic potash solution for many hours at a temperature of 45° to 50° Centigrade. When any kind of mercuric sulphide, black or red, is mixed with 1 per cent. of antimonious sulphide, and sublimed, it yields a product which may be turned into a splendid crimson-red vermilion by being finely ground and then digested repeatedly with liver of sulphur in solution, and then washed and digested with hydrochloric acid; afterwards it is to be washed with pure water and dried. Thus prepared, the product is equal to the best Chinese vermilion. Adulterations in vermilion are numerous, but may be easily detected. Red lead remains behind, as the yellow oxide, when the impure vermilion is strongly heated. Red ochres and burnt clays remain unchanged during this process. Red resins, such as that known as dragon's blood, may be removed from vermilion by warming it with strong spirits of wine. It is, however, found that the saturation of finely-prepared and ground vermilion with a solution of this red resin, and the subsequent drying of the material, protects this pigment to some extent from that liability to become dull and, as it were, tarnished in this lapse of time, which so seriously detracts from its value, when used with size, gum, etc., in distemper and water-colour painting. As the beauty of the tint of vermilion depends upon a nicely adjusted molecular state, it is not difficult to explain its proneness to change.

Cinnabar or vermilion was known to the ancient artists. By Pliny and Vitruvius it is also called minium, which now signifies red lead exclusively. Vermilion is derived from *vermiculus*, a form of the word *vermes*, a worm; it was originally applied to the *kermes*, an insect, a species of *coccus*, found in the south of Europe, and yielding a red dye inferior to true cochineal.

It is unnecessary to say much about red lead, which is an oxide of lead containing 3 atoms of lead and 4 of oxygen. It is very heavy, and difficult to mix with other pigments, or to use safely in decoration or in painting.

Venetian red and Indian red, and numerous other colours of similar hues, are really nothing more than ferric oxide or peroxide of iron, more or less pure. They are excellent and permanent colours which have been abundantly employed in painting from the earliest ages, and are found by long experience to merit entire confidence. *Rubrica* is the Latin name for red ochre, of which that from the isle of Lemnos was most esteemed. All the ferruginous reds which go under the names of light red, Mars red, Mars violet, Venetian red, etc., are distinguished from the yellow and brown ochres by their greater purity, and the absence of water in combination, although they may contain a small quantity of moisture derived from the atmosphere. One of the best of all these native iron reds is a remarkably rich and deep red hæmatite which goes in commerce under the name of Wharton's hæmatite. It contains no less than 94·7 per cent. of pure ferric oxide. We have already mentioned the methods by which ochres, whether yellow or red, may be changed in tint.

We must dismiss the vegetable and animal reds with a few words about the most important of them, namely, those derived from madder and cochineal respectively. The colours from the root of the madder plant, *Rubia tinctorum*, are more numerous when employed in dyeing than in painting. But if the range of the madder pigments is limited, their beauty and comparative stability render them indispensable to the artist. The madder lakes are prepared by precipitating the aqueous extract of madder or of its derivatives with salts of aluminium, or rarely, with iron and tin compounds.

Some of the residual matters obtained in the preparation of the various madder derivatives used in dyeing may be made to yield, by exhaustion with boiling water, a liquor, from which alum or milk of lime precipitates beautiful pink or violet lakes. A good method of preparing a madder lake from the root is to take 4 parts by weight of the root, and thoroughly exhaust them with repeated agitation and pounding with small portions of pure cold water. When all colour that can be thus extracted is removed, add 3 ounces of alum in solution, and afterwards enough solution of potassium carbonate to precipitate all the alumina present. The madder lake thus precipitated is to be filtered off, washed, and dried. Lakes of different tints may be made from the exhausted residue of the above operation by boiling it with water, and adding alum and an alkaline carbonate as above described. The colouring matters of madder, which exist in part only ready formed in the root, are known as alizarine and purpurine: the former of these has been lately made artificially from one of the coal-tar products, anthracene, and is capable of yielding a fine series of colouring substances when united with various oxides. Lakes may be prepared from almost all vegetable colouring matters by the process described above—yellow lake, for instance, from fustic, turmeric, annatto, quercitron, and the berries of certain species of Rhamnus. The cochineal lakes are red, and are known as scarlet and crimson lakes, and as carmine. In order to prepare the lakes of cochineal, the dried insects, *Coccus cacti*, are exhausted with cold or hot water, and the clear extract precipitated with an alkaline carbonate and alum. Carmine, on the other hand, is not a true lake, but is the colouring matter of the cochineal mixed with a little albuminoid substance and fat, coagulated and carried down together, by the addition, to the cochineal extract, of alum or cream of tartar, or salt of sorrel, without an alkali. Pure carmine, unlike the lakes, is soluble in liquor ammoniæ. The commoner cochineal colours are constantly adulterated with preparations of Brazil wood, etc., or else are made from the residues and inferior qualities of cochineal. From the researches of Warren De la Rue it has been ascertained that the true colouring principle of cochineal is an acid, called coccasic acid. And it is not improbable that some of the pure salts of this acid will turn out to be the most permanent forms in which to employ the colouring matter of cochineal.

Lakes and other preparations of lac, madder, and of Brazil wood (from India), were known to the mediæval illuminators and artists. In a document of the reign of Edward III. a sinopre or cynople is spoken of, which seems to have been a madder lake.

Blue pigments in ancient times appear to have been very numerous. Cœruleum, in later times azura or lazura, was the blue mineral known now as chessylite, a mixed carbonate and hydrate of copper; in Pompeian art it was largely employed, as well as another blue, a smalt made by grinding a blue glass coloured either by copper or cobalt. "Indobras" or indigo from Bagdad is spoken of in an English document dated 1228, but it is certain that similar blue vegetable preparations were known to the ancients. Indigo has been found on Egyptian mummy cloths, and is mentioned by Pliny under the name of *indicum*. The modern cœruleum blue is a cobalt stannate, and contains, along with some silica and gypsum, 3 molecules of cobalt oxide to 4 of stannic oxide. It is an excellent and permanent blue with a slight greenish shade, and retains its blue tint, unlike cobalt and ultramarine, when seen by artificial light.

Cobalt blue, properly so called, is prepared by mixing a pure solution of a cobalt salt with a solution of pure alum, and precipitating the mixture with an alkaline carbonate. The precipitate, after thorough washing, is strongly ignited, and forms a rich and permanent blue pigment. Other cobalt blues are in use, but, with one exception, they are less permanent than that just mentioned. Smalt, essentially a cobalt and potassium silicate, is that exception. It is often called cobalt blue, but is not so perfect a colour as the true compound above described. It is a deep blue glass, ground up into a powder, and is perfectly unchangeable by time. It is made extensively in Saxony, by fusing roasted cobalt ore with quartz and potassium carbonate.

The magnificent blue derived from the lapis-lazuli was and is highly esteemed as a pure and permanent pigment. Its preparation from the mineral is tedious and costly. So highly was the natural ultramarine valued by the painters of the best period of Italian art, that before undertaking the grinding of a native lump of the lapis they sometimes made vows and offered special prayers for the success of the work. Now, however, that chemists have succeeded in rivalling the native pigment by a composition which is practically almost identical with it in composition, we may obtain this magnificent blue colour at an insignificant cost. China clay, sodium sulphate, charcoal, and soda are calcined together for some hours in a closed crucible, and the green mass thus obtained is, after grinding and addition of sulphur, once more ignited: it then becomes blue. The blue colour of artificial ultramarine is readily discharged by hydrochloric and other acids. And it has been observed that when mixed with white lead, as in painting skies, the mixed pigments often change from a pale blue to a lilac or grey hue, probably owing to the action of some sulphur compound in the ultramarine upon the lead.

Indigo, a pigment derived from a colourless compound existing in the *Isatis tinctoria*, *Indigofera tinctoria*, and *I. anil*, besides several other plants, differs from the pigments previously studied in containing the element nitrogen. Commercial indigo contains many impurities, and not more than 50 to 60 per cent. of the real colouring matter. It may be purified by reducing it to the condition of the colourless or white indigo, and then exposing the solution of that substance to the air, when a blue powder falls. Or the commercial indigo may be pounded and successively exhausted with cold water, dilute hydrochloric acid, hot water, and alcohol. If plaster of Paris 2 parts, and finely powdered indigo 1 part, be made into thin cakes, dried thoroughly, and then heated on an iron plate, pure crystallised indigo sublimes, and may be scraped off the cakes. Or the indigo may be dissolved in Nordhausen or fuming oil of vitrol, by which two or more complex acid bodies are produced, the salts of which may be employed as pigments. Pure indigo dissolves perfectly, without residue, in cold fuming oil of vitrol. It is scarcely necessary to say that the best and most trustworthy preparations of indigo for painting are those which contain this substance in the greatest purity.

Prussian blue and Turnbull's blue are compounds of cyanogen and iron. Prussian blue is best formed by gradually adding a solution of yellow prussiate of potash, potassium ferrocyanide, to excess of ferric chloride, and thoroughly washing the precipitate of Prussian blue, after having digested it for some time, with a fresh portion of ferric chloride. A similar blue may be made by precipitating ferrous sulphate with yellow prussiate, and oxidising the pale blue precipitate by exposure to the air, or by nitric acid. All the blues of this class should be thoroughly washed from soluble salts, especially if they are to be used in oil-painting. Prussian blue, though destroyed by alkalies, resists the action of acids. If ground with its own weight of oxalic acid, it dissolves, forming a blue paste soluble in water. A soluble Prussian blue may be made, but it is inferior to those already described.

Amongst green pigments one of the most vivid is emerald green: it is, however, poisonous, as it contains both arsenic and copper. It is also inadmissible in silicious painting, is darkened by sulphuretted hydrogen readily, and is similarly affected by some samples of ultramarine and of cadmium yellow. This emerald green, or Schweinfurt green, is a compound related at once to verdigris and to Scheele's green, being a mixed acetate and arsenite, while the latter is a copper arsenite. Verdigris itself is also used as a pigment; it is a basic copper acetate, containing, when of good quality, about half its weight of copper oxide. Besides verdigris (*Vert de Grèce*) the ancients possessed many other green pigments, such as the copper carbonate and hydrate known now as malachite, and still used in this way occasionally; and also various kinds of "green earth," terre verte, minerals containing iron protoxide and of a dull hue. But the modern invention of chrome greens has displaced many of the older and inferior pigments. We refer, of course, to the true chrome greens, and not to the fugitive mixtures, sometimes so called, of chrome yellows with blue pigments. The older chromium greens consisted simply of the sesquioxide of that metal, and, while generally very dull indeed, attained but rarely anything approaching a pure hue. These dry or anhydrous chromium oxides, prepared by ignition of the various salts of chromic acid, vary much in quality, the best being made by heating mercurous chromate in a closed crucible till all volatile matter has been driven off. But the hydrated chromium oxides are of far finer and more translucent hues than the dry. One of the best of these is Guignet's green, introduced into this country as viridian. It is, in reality, a compound of chromium sesquioxide, water, and boracic acid, containing about ¾ of its weight of the first-named substance, and is prepared by calcining together 3 parts of crystallised boracic acid and 1 of potassium bichromate. The product is ground and washed, and constitutes a splendid and permanent pigment. When ammonium phosphate and potassium bichromate are heated together to 180° Cent., they yield another fine green, Arnaudon's green.

It is scarcely necessary to add anything concerning brown and black pigments, beyond the statement that the former, such as amber or raw sienna, consist chiefly of ochres and of vegetable lakes already described; while the latter are either permanent preparations of carbon—as, for instance, lamp-black, Indian ink, and ivory black—or else are organic products such as sepia, the stability of which secretion is pretty well assured from the observation that the ink-bag of the fossil cuttle-fish has been found to yield as excellent a sepia as that of the *Sepia officinalis* now living. Brown and black pigments containing bitumen are very treacherous in use, owing to the marked effects of temperature upon such materials.

We have not alluded as yet to any of the beautiful "aniline colours" or "coal-tar colours," now so extensively employed in dyeing, since, for the most part, they do not possess a sufficient degree of permanence to be safely used in painting. Yet it is possible that a few of these magnificent colouring matters, related to mauve, rosaniline, peonine, azuline, Manchester yellow, emeraldine, etc., may hereafter be found capable of use in painting. Experiment in this direction is greatly needed, yet it must be owned that there are other difficulties besides that of want of permanence to be surmounted. These colours are not usually soluble in any available solvent, nor do they show their hues when merely ground. So a white basis is generally necessary. Pure whitening may be used successfully for obtaining a violet tint with mauve. A strong hot alcoholic tincture of mauve is to be poured upon warm and dry whitening, which is then dried and ground. The process is repeated till sufficient depth of tone is obtained. This method is merely here suggested for a more extended trial, and with other coal-tar pigments, since the mauve pigment thus prepared has changed, though only to light extent, since it was first used in 1860.

SANITARY ENGINEERING.—XII.

VENTILATION.

Few subjects have within the last few years attracted more public attention than ventilation, or, as we may term it, the theory of supplying fresh wholesome air to crowded rooms, where either from the necessities of their occupation, when used for manufacturing purposes, or the accidental circumstances of their public use for meetings, etc., the consumption of wholesome atmospheric air is greater than the supply; but there is the no less important question previously arising as to the best method of ventilating or supplying fresh air to ordinary living rooms, so as to secure the maximum of comfort with the minimum of inconvenience. We do not propose to go very deeply into the scientific aspects of the question: in our present paper we shall confine ourselves to a general statement of what are the general principles to be observed, and a description of some of the best modern appliances for the purpose; while in some subsequent articles we may deal with the subject as applied to public buildings with large audiences and others, where a special class of difficulties has to be dealt with—*e.g.*, hospitals, where, in addition to the ordinary deterioration of the atmosphere by respiration, foul air and the seeds of absolute disease have to be encountered and remedied.

In some previous papers on Warming, we have described the way in which heat is made available to secure, by means of water, a circulation: the first principle being that hot water is lighter than cold, and will always rise through it to the surface; and a wider and more extended application of the same principle—*i.e.*, that hot air is lighter than cold, and will rise through it—is the base of all efficient systems of ventilation, with this difference, however, that the hot air is not available for return purposes, as in the case of hot water, but has to be got rid of, together with, in many cases, a considerable volume of comparative impurity arising from respiration and the proceeds of combustion.

As a familiar illustration of the natural consequence of insufficient ventilation in ordinary dwelling-houses, we may venture to remind our readers, many of whom have doubtless experienced the effect, that when by some accident it becomes necessary either to reach a book from a lofty shelf, or, for some necessary attention to a lamp, to climb into a position above the top of the door of an ordinary room, if the window happen to be closed, a sensation is at once experienced as if a different atmosphere were entered; there is a rise of temperature of many degrees, and, especially if the room is lighted by gas, a sense of discomfort from the presence of vitiated air, the product of combustion, is felt; if at the same time the door be set ajar, a candle held at the top will indicate a strong *outward* current of air, and when the same candle is held at the bottom a strong *inward* current, the top of the room above the door forming a sort of inverted receiver for the vitiated air of the apartment. We take a simple case first, as an illustration of the difficulties to be dealt with, which are similar in most cases.

In winter we suppose, of course, a fire in the room; this creates a strong up-draught in the chimney, and removes from the lower part of the room all vitiated air; but the modern method of stove construction brings the fire within a very short distance of the floor, and therefore this influence can scarcely be said to extend above the level of the mantelpiece; from this level to about, say, 7 feet 6 inches high, the air of the room is under the control of the door; and above that level, when there is no means of opening a window, and no artificial means of ventilation provided, the air becomes, as we have said, a permanent hot-air bath. The temperature to be maintained in any ordinary sitting-room is of course most variable, according to the habits of its inmates, and the warmth or otherwise of the external air. Some families are constitutionally tender, and others, to use a common phrase, cannot have too much fresh air; but each and all, by attention to a few simple rules, can regulate the temperature of their rooms to their own liking.

Our forefathers had never any trouble with the question of ventilation. The old system of wainscoting walls provided for the admission of air by innumerable crevices, and for its exit in the same way; and if the power of the fire was sufficient to warm the room, nature did the rest; but in our modern days our plastered ceilings and walls effectually prevent any such spontaneous result.

Englishmen, as a rule, like fresh air, and Continental travellers frequently complain of the closeness engendered by the radiating stoves in use abroad, and often in railway carriages there is the greatest objection on the part of the "natives" to letting down a window: the reason for this we do not intend to assign; we simply state it as a well-known fact—they are terribly afraid of draughts. At the same time there is no more common cause of cold than an open window, or, as it is commonly called, sitting in a draught.

We will now return to a simple statement of the objects to be obtained by ordinary domestic ventilation. The hot air at the top of the room, as a usual rule, is impure, and has to be got rid of; and the fresh air, which is the cold external air, has to be admitted without creating such a draught as may be either unpleasant or injurious. The obvious conclusion is that the hot air must be allowed to escape at the top of the room, and the fresh air must be admitted from the bottom; the intermediate action of the fire being always taken into account: as a general rule, a *down draught* from a ventilator in the upper part of the room is a mistake, and likely to be mischievous. As a further homely illustration of these general principles, we may mention the not uncommon case of a fire which will not draw when first lighted, and the chimney smokes: by opening a door or a window, or both as the case may be, the requisite supply of fresh air is obtained, and everything goes on satisfactorily.

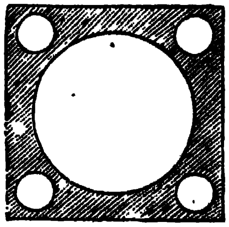


Fig. 1.

The actual demand of a fire for a supply from the external air is well exemplified by an invention recently brought out, and which, we believe, is the subject of a patent. A flue is constructed of terra-cotta, circular in the central opening, but enclosed in a square envelope, as we may term it, the spandrils at each corner being independent of the flue, but forming separate air-ducts, communicating with the atmosphere of the room: a section of this is shown in Fig. 1. It might be surmised that the heat of the flue diffused through the surrounding ducts would cause an upward current, and so draw from the room the air, especially from the upper portion: it is, however, found in practice that exactly the converse result takes place, and that the ordinary draught of the fire, when a room is in its normal state, is sufficient to bring a very marked *down draught* through these auxiliary flues. In a previous paper on heating by warm air, we alluded to a system by which the outer iron case of the stove, specially constructed for the purpose, had a direct communication, by means of a channel or pipe, with the external air, which was by this means introduced into the room at a higher temperature; and this is a system the adoption of which may be safely recommended.

In any case, if the stove be not constructed for the purpose, a small flue communicating with the outside of the building and with openings provided either in the hearth, or in the jambs of the chimney at the level of the fire, will be found a most important assistance to a smoky chimney, and have a generally beneficial effect upon the atmosphere of the room. An air-brick introduced in the wall between floor and ceiling, and small holes dispersed at intervals along the side of the room, will also assist in providing fresh air without creating a draught. Another plan is to introduce a panel of perforated zinc in the lower panel, or even the bottom rail of the door, a plan often adopted with advantage; and the skirting of the room, if of wood, may readily be made available in a similar way. Provision being made for the admission of fresh air from below, which should be by small openings, so as to avoid the influx of such a body of air as would create a sensible draught, the next step is to provide for the removal of the vitiated and heated air above.

Perhaps one of the best known and most generally adopted expedients for this purpose is Dr. Arnott's ventilator: this is a small valve, generally about 9 inches long and about 6 inches high, opening into the room just below the ceiling level, and communicating with the chimney, and is generally made of metal of ornamental character. In some recent improvements, however, light sheets of talc in metal frames have been adopted: the valve is hung from the bottom, and is provided with a small balance weight adjustable by a screw; this should be so nicely set, that when the temperature of a room rises above a certain point, the valve should open and allow the vitiated air to escape up the chimney, closing itself again by an automatic action when the balance is restored; they are also provided with lines, which enable them to be permanently closed when not required—*i.e.* when there is no fire—as they are entirely dependent for their action upon the draught of the chimney.

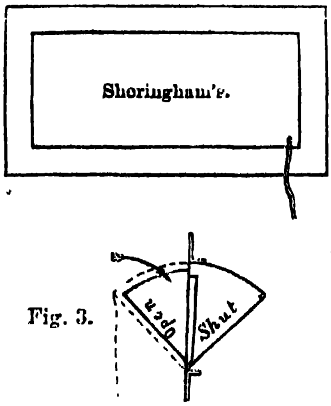


Fig. 3.

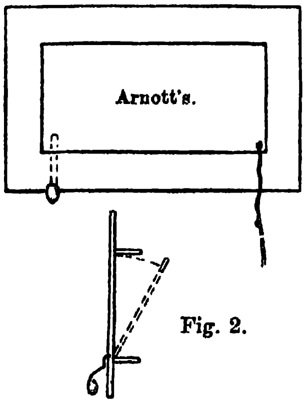


Fig. 2.

Another class of ventilator, commonly called Sheringham's, is constructed with a hopper, which is also controlled by a line, and when open falls forward into the room in the shape of a small quadrant (Fig. 3). The above figures will explain the comparative action of the two, Sheringham's ventilator being intended to communicate with the external air.

The object of this latter construction is to prevent down draughts; but much depends upon the judgment exercised in its use, as should the opening be allowed to be larger than is sufficient to allow of the exit of the heated air, a volume of cold air will certainly rush in, and a down draught result.

This will especially be the case should the adits provided for fresh air from the lower part of the room be insufficient to supply what we may call a free draught to the fire: the heated upward current being once well established in the flue, will certainly draw its supply from any available point, and should the demand be made upon the ventilator, a draught more or less direct from the opening to the fire will be the result.

One very simple and ingenious plan we have seen adopted for introducing fresh air at what we may call the intermediate level with satisfactory results. The bottom rail of the ordinary window sash is made of double thickness or depth, all the other proportions remaining the same, the effect being that the sash can be lifted from one inch and a half to two inches without admitting air at the level of the sill; this affords a means of ingress for cold air, or egress for hot, according to circumstances. This method is explained by the sketch in Fig. 4.

Another very efficient and easily adopted expedient for providing ventilation without direct draught, is by means of a telescopic tube of perforated zinc (Fig. 5), which may be affixed to any window when wanted, and removed when not required: as it can be adjusted to any length it will fit any window, and provides a ready means for the exit of hot air; it is made in two pieces which slide one within the other. The upper sash has to be pulled down three or four inches, the tube introduced between the beads, when the sash being simply pushed up against it holds it in its place.

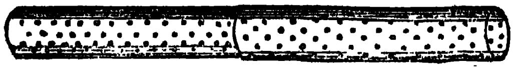


Fig. 5.

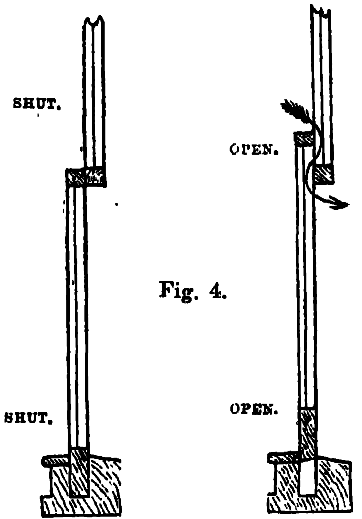


Fig. 4.

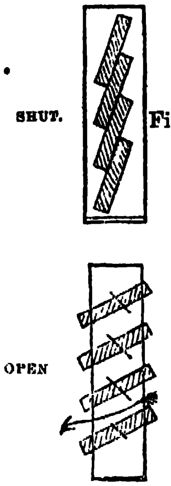


Fig. 6.

Moore's ventilator is an arrangement for the admission of fresh air without loss of light (Fig. 6). One or more of the panes of glass of the window, as the case may require, are occupied by strips of glass which overlap each other, and are hinged so as to be opened at pleasure, while the louvre-like arrangement thoroughly excludes the weather. By lines adjusted for these purposes, the ventilators are thoroughly under control, and the temperature can be regulated with great nicety.

Sometimes, with a view to the same object, what is called a "hit or miss" ventilator is adopted (Fig. 7): this form of ventilator is generally made circular, and consists of two plates of glass perforated with holes of any size, which exactly correspond with either, and have spaces between them of rather greater area than the openings themselves: by means of a pin and small handle, one of the plates of glass is movable, the other being fixed. When so adjusted that the openings coincide, the full amount of ventilation is obtained; when the contrary is the case, the air is thoroughly excluded. In the sketch the ventilator is supposed to be closed, the dark lines representing the openings in the one plate, and the dotted lines those in the other: it will be seen that by about one-eighth of a revolution the openings in the two plates are made to coincide, and by an intermediate position a regulated result may be obtained.

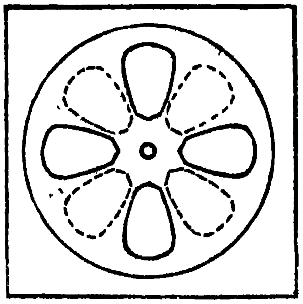


Fig. 7.

In the construction of the cornice of an ordinary room, openings may be provided for ventilation with good effect, and ornamental centre-flowers may be utilised for the same purpose, and there are also many other inventions of a similar character which our space will not allow us to notice. Our own view is that the general principle stated at the commencement, the distributed admission of fresh air at a low level, and the regulated escape of heated air at the upper level, the balance of circulation being maintained with judgment, will be found, with the aid of the many appliances available for that purpose, the true system of comfort in domestic ventilation.

SEATS OF INDUSTRY.—XIX.

KIDDERMINSTER.

BY WILLIAM WATT WEBSTER.

THE manufacture of carpets on a large scale is an industry of comparatively recent origin. Till about the middle of the last century, the consumption of carpets in Great Britain was exceedingly trifling, and a very few generations ago they were only partially used even in the houses of the aristocracy and gentry. At the present time England and America are the only countries where carpets are in almost universal use, and, consequently, where their manufacture has attained any considerable importance. In 1735, carpet manufacturing was first introduced into Kidderminster, and from that date to this the name of the town has been intimately associated with the English carpet trade.

Kidderminster is a municipal and parliamentary borough in the county of Worcester, situated on the river Stour, about four miles above its junction with the Severn, at a distance of fifteen miles to the north of Worcester, and 125 miles to the north-west of London. The town is built on rising ground on the banks of the Stour, and was called *Chiderminster* by the Saxons, *Chid* in British signifying a hill, and *dur*, water. Little is known of the history of the place previous to the reign of Henry II., except that it was a royal manor. That sovereign gave it to the Bassetts, from whom it passed to the Beauchamps, Nevilles, Cookseys, Blounts, Foleys, and to Waller the poet, and it is now the property of the Earl of Dudley. In the time of Edward I. Kidderminster returned members to Parliament, and in the beginning of the sixteenth century it was noted for the manufacture of broadcloth. The earliest charter of incorporation that has been discovered dates from the twelfth year of Charles I., but it claims to be a borough by prescription. In the eighth year of George IV.'s reign Kidderminster obtained a new charter for the acquisition of lands, and an increase in the number of magistrates, which had been limited by the previous charter to two. The right of the borough to return members to Parliament which had lapsed through desuetude, was renewed by the Reform Bill of 1832, and since that date Kidderminster has sent one member to the House of Commons. Under the Municipal Act of 1835, the town was divided into three wards, and placed under the government of a mayor, six aldermen, and eighteen councillors. Kidderminster was celebrated for its manufacture of worsted, or of worsted and silk goods, and subsequently for bombazines, plushes, and poplins, before it became famous for its carpets.

About the year 1775, forty years after the manufacture of carpets had been introduced into the town, there were in Kidderminster 1,700 silk and worsted looms, each employing one weaver, and 250 carpet looms, each employing a man and a boy, the total number of persons employed in both branches of manufacture being about 5,000. By the year 1830 the number of silk and worsted looms was reduced to 700, while the number of carpet looms had increased to about 1,000. In 1838, the hand-loom weavers' commissioner reported that there were in Kidderminster in that year 2,021 carpet looms in operation, besides 80 looms for bombazines, and about 400 looms unemployed. From the parliamentary returns of mills and factories of the same date we learn that there were then in the town and neighbourhood six worsted mills employing a total of 622 hands, 1,765 looms for making Brussels carpets, 210 looms for Scotch carpets, and 45 for Venetian carpets. The total number of persons employed in the weaving trade at Kidderminster was at that time stated to be 1,905 men, 351 women, and 1,760 children; in all, 4,016. In 1801, the population of Kidderminster numbered 6,110; in 1811, 8,039; in 1821, 10,709; and in 1831, 14,981. In 1851, the town contained 18,462 inhabitants, but by 1861 its population had declined to 15,399, and at present, in 1871, it is 20,800.

The hand-loom weavers' commissioner, from whose report a quotation has already been made, furnishes some interesting information in reference to the reductions that took place in the wages paid to the weavers of Kidderminster, during the twelve years that preceded a great struggle between the workmen and their masters in 1828, which is the most memorable event in the industrial annals of the town. "I find," he says, "that in 1816 wages were reduced 17 per cent., and in 1828 a further reduction of 17 per cent., and even of 20 per cent. in comber-work took place; say 34 per cent. of a total reduction since the termination of the war. Trade has suffered," he adds, "not in the quantity produced, but in the decrease of profits." In the spring of 1821, the masters lowered the rate of wages from 1s. to 10d. per yard, and a strike ensued which lasted from March to August, entailing terrible disasters on the employés, great loss to the employers, and severe, permanent injury to the trade of the town. Previous to the strike, many of the weavers had little sums of money laid aside, and owned the cottages in which they lived. Benefit clubs had also been established, and were in a prosperous condition. But when the struggle was over the great majority had spent their savings, sold their property, pawned their furniture, while many had migrated, and those who remained returned to their work listless and penniless. Orders that had previously been executed in Kidderminster were sent to Scotland, and many of the weavers went there and found employment. The prolonged poverty the workmen endured is said to have exercised a deteriorating influence on their character, and the Kidderminster weavers have never regained the position they held before this strike. Although the masters won the day, they irrecoverably lost a considerable portion of their trade, and their victory may be described in the Duke of Wellington's words, as hardly less disastrous than a defeat would have been.

The principal centres of carpet manufacture in England are, Kidderminster; Wilton, in Wiltshire; Axminster, in Devonshire; Yorkshire; and in Scotland, Kilmarnock, Edinburgh, and Stirling. About ten years ago, the number of carpet looms in Great Britain was estimated at about 4,000, and the yearly produce at about £1,000,000. In the year 1866, 7,600,511 yards of carpets and druggets, manufactured in the United Kingdom, were exported, the total value being about £1,217,682. The greater part of the carpets exported from Great Britain are sent to the United States of America. A few carpets of exquisite patterns and colours are still imported into this country from Turkey and Persia, but they are now nearly equalled by the best of the carpets produced at Axminster, at Wilton, and in Scotland.

The carpet known by the name of Kidderminster is still manufactured in the town, but it is now produced in much larger quantities in Scotland and in Yorkshire. It is the Brussels and Wilton carpets, which are composed of linen and worsted, that now constitute the most important branches of the trade carried on in Kidderminster, but tapestry or Venetian carpets are also made there in considerable quantities. The manufacture of the cut-pile or Wilton carpet was introduced into the town in 1749. Kidderminster has a high reputation for the excellence of its carpet fabrics, the elegance of the designs, and the durability and brilliancy of the colours. Various other kinds of woollen goods are manufactured in Kidderminster, and there are several extensive worsted spinning-mills in the town and the vicinity. Large quantities of finger-rings, damask silk goods (used in upholstery), silk coverings for buttons, and waistcoat pieces are also made in Kidderminster, and it possesses iron-foundries, malting-houses, breweries, a paper mill, wire-works, brick-fields, dye-works, and tanneries.

The town of Kidderminster consists principally of small, humble houses, and the streets are irregularly laid out, but clean, well paved, and well lighted. Among the public buildings, the most noteworthy are the Town Hall, a large brick structure with police station and prison cells attached; and the Public Rooms and Corn Exchange, a noble pile completed in 1855, containing a Music Hall, an Exchange, rooms for a Free Library, a School of Design, a news-room, class-rooms, etc. The parish church, dedicated to St. Mary, is a spacious edifice, with a square tower supported by massive buttresses, crowned with decorated battlements and pinnacles, and containing a peal of eight bells. The building is adorned with several ancient brasses and effigies—one being that of a Crusader—and with monuments of members of the Blount and Cooksey families, and one to the father of Lord Somers. Over the altar of St. George's Church, which was erected in 1823, under the sanction of the Commissioners for Building New Churches and Chapels, at a cost of about £16,400, there is a beautiful specimen of Kidderminster carpet-weaving, representing the descent from the cross. The Baptists, the Independents, the Roman Catholics, the Wesleyans, the Primitive Methodists, and the Unitarians have all chapels in Kidderminster. Richard Baxter, the celebrated Nonconformist divine, held the living of Kidderminster until the time of the

Restoration; and when the corporation chest was opened in 1838, it was found to contain, among other curious relics and documents, a very old edition of "Baxter's Saints' Rest," on the title-page of which was the following inscription in the author's handwriting:—"This book being devoted, as to the service of the Church in general, so to the church at Kedderminster, the author desires that this book may still be kept in the custodye of the high bayliffes, and entreateth them carefully to read and practise it, and beseecheth the Lord to bless it to their true reformation, consolation, and salvation.—Richard Baxter." The Free Grammar School of Kidderminster, founded in the reign of Charles I., has a revenue of upwards of £500 per annum. Clare's Almshouse, founded by Sir Ralph Clare in 1670, and Blount's Almshouse, founded by Sir Edward Blount in 1630, are the most important charities in the town. At Roundhill, about half a mile from Kidderminster, there is a chalybeate spring, and there is another strongly impregnated at Sandburn. On Burlish Common there is a dropping well, which was once celebrated for the cure of disorders of the eye.

PRINCIPLES OF DESIGN.—XXIV.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

GLASS.

WHEN speaking of earthenware, I insisted upon the desirability of using every material in the easiest and most natural manner, and I illustrated my meaning by saying that glass had a molten condition as well as a solid state, and that while in the molten condition it can be "blown" into forms of exquisite beauty. Glass-blowing is an operation of skill, and an operation in which natural laws come to our aid, and I cannot too strongly repeat my statement that every material should be "worked" in the most simple and befitting manner; and I think that our consideration of the formation of glass vessels will render the reasonableness of my demand apparent.

Let a portion of molten glass be gathered upon the end of a metal pipe, and blown into a bubble while the pipe drops vertically from the mouth of the operator, and a flask is formed such as is used for the conveyance of olive oil (Fig. 92); and what vessel could be more beautiful than such a flask? Its grace of form is obvious; the delicate curvature of its sides, the gentle swelling of the bulb, and the beautifully rounded base, all manifest beauty.

Here we get a vessel formed for us almost wholly by nature. It is the attraction of gravitation which converts what would be a mere bubble, or hollow sphere of glass, into a gracefully elongated and delicately-shaped flask. This may be taken as a principle, that whenever a material is capable of being "worked" in a manner which will so secure the operation of natural laws as to modify the shapes of the objects into which it is formed, it is very desirable that we avail ourselves of such a means of formation, for the operation of the laws of gravitation and similar forces upon plastic matter is calculated to give beauty of form.

When clay is worked upon the potter's wheel, it is shaped by the operator's skill, and is sufficiently stiff to retain the shape given to it to a very considerable extent, yet the operation of gravitation upon it, so long as it has any plasticity whatever, is calculated to secure delicacy of form. This rule should ever be remembered by the art-student—that a curve is beautiful just as its origin is difficult to detect (see Vol. I., page 279). In the formation of vases, bottles, etc., knowledge of this law is very important, and the operation of gravity upon hollow plastic vessels is calculated to give to their curves subtlety (intricate beauty) of character. Having arranged that the material shall be worked in the manner most befitting its nature, we must next consider what purpose the object to be formed is intended to serve.

Take a common hock-bottle (Fig. 93) and consider it. What is wanted is a vessel such as will stand, in which wine can be stored. It must have a strong neck, so that a cork may be driven in without splitting it, and must be formed of a material that is not absorbent. Glass, as a material, admirably answers the want, and this bottle is capable of storing wine; it will stand, and has a rim around the neck such as gives to it strength. But, besides serving the requirements named, it is both easily formed and is beautiful. The designer must be a utilitarian, but he must be an artist also. We must have useful vessels, but the objects with which we are to surround ourselves must likewise be beautiful; and unless they are beautiful, our delicacy of feeling and power to appreciate nature, which is full of beauties, will be impaired. A hock-bottle is a mere elongated bubble, with the bottom portion pressed in so that it may stand, and the neck thickened by a rim of glass being placed around it.

Here we have a bottle shaped by natural agency; it is formed of heavy glass, and the bubble was thick at its lower part, hence its elongated form; but if length is required in any bubble, and the glass is even light, it can always be given by swinging the bubble round from a centre, so that centrifugal force may be brought into play in the direction of its length; or if it has to be widened, this can as easily be done by giving to it a rotatory motion, whereby the centrifugal force is caused to act from the axis of the vessel outwards, and not from the apex to the base, as in the former instance. In either case a certain amount of beauty would appear in the shape produced, for Nature here works for us.

Our wine-bottles are moulded, hence their ugliness. We work without Nature's assistance, and we reap ugliness as the reward. Let us now consider what a decanter should be. In many respects, the wants which a decanter is intended to meet are similar to those which are met by the bottle, as just enumerated, but here is a great difference—a bottle is only *intended* to be filled once, whereas a decanter is intended to be filled many times; and a bottle is made so that it can travel, while a decanter is not intended to be the subject of long journeys. It is true that a bottle may be re-filled many times, but it is not intended that it should, as the fact that we use a funnel when we wish to fill it clearly shows, and without a funnel the vessel is not complete. All objects when intended to be re-filled many times should have a funnel-shaped mouth (see my remarks on the Greek water-vessel, Vol. II., page 376), but if a bottle had a distended orifice it would not be well adapted for transport. A decanter should have capacity for containing liquid; it should stand securely, and should have a double funnel—a funnel to collect the fluid and conduct it into the bottle, and a funnel to collect it and conduct it out of the bottle. It must also be convenient to use and hold, and the upper funnel should be of such a character that it will guide the liquid in a proper direction when poured from the decanter.

If we take a flask and flatten its base, and extend the upper portion of the neck slightly into the form of a funnel, we have all that is required of a decanter, with the exception of a permanent cork, which is a stopper (Fig. 94).

But as most decanters are intended to hold wine, the brilliancy of which is not readily apparent when that portion of the vessel which contains the liquid rests immediately upon the table, it is desirable to give to the vessel a foot, or, in other words, raise the body of the decanter so that light may surround it as fully as possible (Figs. 95 and 96).

In Figs. 97 to 108* I give a number of shapes of decanters and jugs, such as may be seen in our best shop-windows, and such as I consider desirable forms for such vessels; and in considering the shape of such vessels, the character of the upper portion of the neck must be regarded, as well as that of the body and base.

Besides decanters and bottles, glass is formed into tumblers, wine-glasses, flower-holders, and many other things; but the principles which we have already laid down will apply equally to all, for if the objects formed result from the easiest mode of working the material, and are such as perfectly answer the end proposed by their formation, and are beautiful, nothing more can be expected of them.

Many objects of fancy shape have been produced as mere feats of glass-blowing, and with some of the efforts I sympathise. Wherever the work produced is truly adapted to use, or where an artistic effect is achieved, the glass-blower has my warm sympathy, but if the effort is made at the production of novelty merely, the result gained is sure to be unsatisfactory. Much of the Venetian glass will illustrate these last remarks.

Fig. 109 is a very excellent and picturesque spirit bottle; it is easy to hold, and quaint in appearance.† Figs. 110, 111, and 112 are Venetian glass vessels, wrought entirely at the

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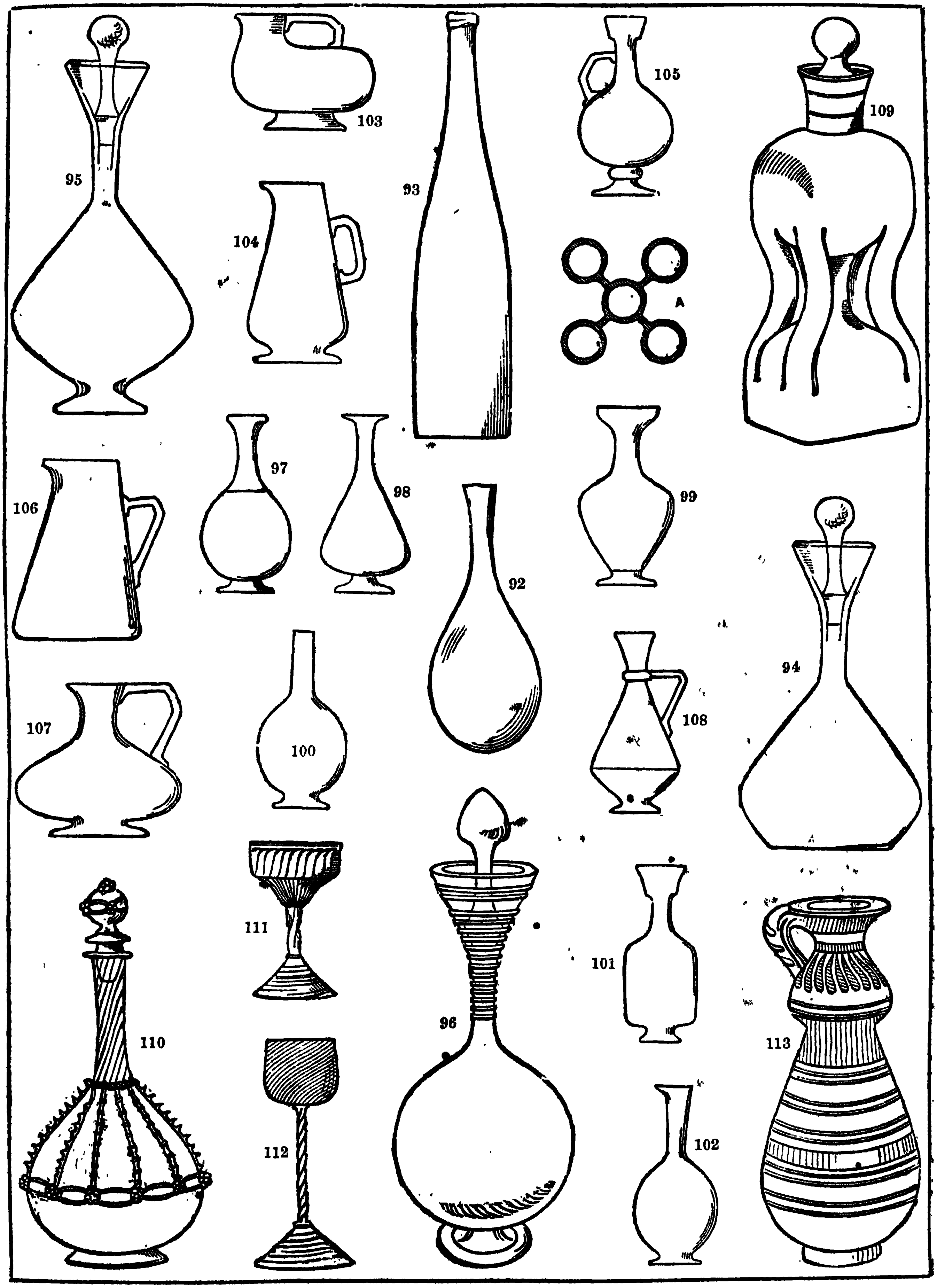
* Respecting the application of handles to vessels I will speak when noticing silversmiths' work.

† In order that the nature of this bottle be better understood, I give a section of it at A.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furnace mouth, and neither cut nor engraved—they are artistic, and of interesting appearance; while Fig. 113 is a work of Roman glass, in which the upper distension is useful if the liquid contains a sediment which it is not desirable to pour out with the liquid.

FARMING AND FARMING ECONOMY.—VII.

By Professor Wrightson, Royal Agricultural College, Cirencester.

Forage or green crops are represented principally by a few familiar species, for the most part belonging to the natural orders *Leguminosæ*, *Cruciferæ*, and *Gramineæ*. There are besides these a considerable number of plants grown to a limited extent which demand a passing notice.

LEGUMINOUS FORAGE PLANTS.

The vetch or tare (*Vicia sativa*) includes summer and winter vetches: the first, a quick-growing variety, sown in the spring; the second, hardier, and sown in the autumn. Both are extensively cultivated, and although suitable for all classes of land, prefer those of a calcareous character. Vetch cultivation commences immediately after harvest, and proceeds as follows: If the land is foul, it should be thin-ploughed or pared (*i.e.* cultivated to the depth of about two inches), rolled, and harrowed; the weeds should then be collected, burnt, and the ashes spread; twelve to fifteen single horse-loads of manure carted on to the land, spread, and ploughed in, with a moderately deep furrow. The earliest winter vetches are planted towards the end of August; the second sowing takes place a month or six weeks later, and sometimes a third sowing is effected before winter. It is not advisable to plant this crop later than the 15th of November. The cultivation for spring vetches is similar to the above. The work should have been accomplished in the winter, so that the seed may be sown as soon as a suitable opportunity presents itself in early spring. Consecutive sowings at intervals of a month may be persevered in until the latter end of May. By this system an excellent food for stock is provided from the beginning of May to the end of September, when turnips will be fully ready for use. Vetches are sown by the drill in rows eight inches apart, at the rate of 2½ bushels of seed per acre, to which, in the case of winter vetches, half a bushel of winter oats, rye, or, better still, beans, has been added to support the plants. The after cultivation consists in rolling, and hoeing, if necessary. The crop is consumed on the ground by sheep, or cut for horses and horned stock. For lambs, vetches can scarcely be used too young, but old sheep and horses will thrive better upon them when the pods are filling with seed. They are ready for consumption when just coming into flower.

V. sativa is the only species cultivated in this country.

M. Heuzé and Professor Wilson describe several other species as (1) the white or American vetch, also called the Canadian lentil, with white seeds and violet flowers; (2) the large-podded vetch (*Vesce à gros fruits*) (*V. macrocarpa*); (3) the Hopetown or Scotch vetch with white flowers; (4) the Siberian vetch (*V. biennis*); (5) the tufted vetch (*V. Cracca*); (6) the Russian vetch (*V. villosa*); (7) the yellow-flowered vetch (*V. lutea*); (8) wood vetch (*V. sylvatica*); (9) narrow-leaved vetch (*V. angustifolia*); (10) Narbonne vetch (*V. Narbonensis*); (11) saw-leaved vetch (*V. serratifolia*), to which we may add the Australian vetch lately imported by the Messrs. Carter of London.

Red clover (*Trifolium pratense*) was introduced into this country by Sir Richard Weston, Ambassador to the Low Countries, in 1645. This plant thrives upon a large variety of soils, but best upon calcareous clays and loams. It is universally cultivated alone, and as an ingredient of mixtures for pasture. It usually follows a corn crop after fallow or roots, and occupies the ground profitably for one year. It is sown upon young barley or wheat in April with the drill or the broadcast barrow, the former plan being the best, at the rate of 20 lb. per acre. The land should be Cambridge-rolled previously to sowing, and subsequently brush or chain harrowed.

Red clover is liable to clover sickness, *i.e.* to fail upon land which has frequently grown it. The reason of this is obscure, but probably it is a deficient supply of plant-food. Applications of lime, liberal management, and intervals of eight years between crops of red clover, are the best means for ensuring success. The young plants may be lightly stocked with sheep in the autumn, but all stock should be removed before frosty weather sets in. The crop may be mown or fed, and will yield about 10 tons of green food, or 2½ tons of excellent hay.

Crimson or scarlet clover (*Trifolium incarnatum*) is an annual differing widely from the last species. The "flowers" of red clover are purple, globular, and sessile; while those of *incarnatum* are crimson, elongated, and supported on a stalk. There are two cultivated varieties, the first scarlet, the second a light pink or French white. Crimson clover was introduced into France in 1791 by Prince Pré de Buire, and into Berwickshire in 1821 by Sir John Sinclair. It is usually sown in the autumn upon corn stubbles. The only cultivation necessary is to harrow the surface, sow the seed broadcast at the rate of 14 lb. per acre, and to roll or harrow it in. The crop is cut in May, and the land is then broken up for roots. This method of cultivation is suitable for free working and clean land only.

White Dutch clover (*T. repens*) is useful in two-year old pastures when the red clover has in a great measure died out. It is never sown alone.

Alsike or Swedish clover (*T. hybridum*) was originally brought from Sweden by Mr. George Stephens of Edinburgh. The seed thus introduced was planted by the Messrs. Lawson in Meadowbank Nursery, April 17, 1834. This plant grows vigorously, and is an important ingredient in mixtures for one, two, or three years' pasture. It is suitable for moist, cold soils, and has been exceedingly luxuriant during the past cold summer. It has white and pink flowers and a vigorous habit of growth. The seed is very small, and a comparatively small quantity per acre, generally about 2 lb., mixed with others, is sufficient.

Zigzag clover (*T. medium*); hop trefoil (*T. procumbens*); suckling clover (*T. filiforme*); Egyptian clover (*T. Alexandrinum*); Alpine red clover (*T. alpestre*), and *T. elegans*, a plant closely resembling Alsike clover, are among other cultivated species of this family, but the above four species are the only ones widely cultivated in Britain.

Trefoil, "Nonsuch," black medick, or yellow clover (*Medicago lupulina*), is a general favourite with farmers, and is either sown alone or mixed with other clovers and grasses. It usually follows barley and precedes wheat, and is sown upon the young corn in March or April at the rate of 18 lb. per acre. It is especially suitable for dry, chalky soils, and affords early sheep keep the succeeding spring. Lucerne (*Medicago lupulina*) was well known to the ancients, and is extensively cultivated in all southern countries. It was introduced into England in the seventeenth century, and into Lothian by the Earl of Haddington, and Mr. Cockburn of Ormiston, between the years 1720 and 1730 (Wilson). It succeeds best upon dry calcareous soils, and improves in productiveness for three years after sowing, and may be profitably left in possession of the ground for from eight to ten years. It is sown upon clean, well-cultivated land in March, at the rate of 10 lb. per acre, in rows fifteen to eighteen inches apart, and the after cultivation consists in keeping the land clean by hoeing.

M. maculata, spotted medick or hedge-hog plant, and *M. falcata*, yellow lucerne, are used occasionally as forage crops, although seldom or never seen in the agriculture of this country.

Closely allied to the above trifoliate plants are the Melilots, *officinalis* and *leucantha*, and the bird's-foot trefoil (*Lotus corniculatus*), used in mixtures for permanent pastures.

Sainfoin (*Onobrychis sativa*) and its variety *bifera* are also importations from the Continent of Europe. Heuzé informs us that sainfoin was introduced into England in 1651, but does not say by whom. In the south-west of England, and especially on the Cotswold hills, it is a favourite crop, and in other parts of this country it forms an ingredient in mixtures for two or three years' pasture. It affects dry limestone soils, and resists long continued drought successfully. On the Cotswolds it is drilled across the young barley at the rate of 3½ to 4 bushels of unmilled, or 50 to 60 lb. of milled seed per acre, the former being preferred. A small quantity of trefoil should be mixed with the sainfoin seed to assist in occupying the ground the first year, when the sainfoin is somewhat feeble. Young sainfoin should be mown the first year, as grazing tends to check its development. After the first season it is stocked with sheep, and it remains in possession of the ground for six or seven years.

Gorse (*Ulex Europæus*), known also as furze and whin, is cultivated with advantage upon poor land. It is sown in March or April at the rate of 35 to 40 lb. of seed per acre, in rows ten inches apart, upon properly prepared ground. The crop is ready the second autumn after sowing, and is cut with a heavy hook, tied into bundles of about 20 lb. each, and stored. 2,000 such bundles, or about eighteen tons per acre, is considered a good crop. The gorse requires to be broken in a Walsh's bruiser, or upon a block by a mallet, before it is given to stock, and when so treated cattle and horses relish it.

Kidney vetch (*Anthyllis vulneraria*) may be used on dry sandy soils. It does not give a large yield, but is greedily eaten both by horses and cattle, and stands alike great heat and drought (Lawson and Sons).

CRUCIFEROUS FORAGE CROPS.

Rape (*Brassica campestris olifer*), the colza of the Continent, is widely cultivated. It is also called "smooth-leaved summer rape," to distinguish it from "rough-leaved winter rape" (*Brassica Napus*). Of these two species, the first has smooth, fleshy, glaucous-tinted leaves, while the second has rougher leaves of a vivid green colour. This description of the leaf refers to the mature plant. The author has never seen the latter species cultivated in this country, but the former, also known as coleseed, is familiar to every farmer. This plant is probably a cultivated variety of the swede in which the development of the bulb has been sacrificed for the production of leaves and seeds. It is suitable for any sort of land, but succeeds best upon peaty soils, as in Lincolnshire, where it produces a surprising amount of sheep-food. It is also a favourite in all sheep districts, where it is looked upon as a good introduction to turnips and winter food. It also enables the farmer of clay land to maintain sheep stock in the summer, although, from the nature of his land, debarred from extensive root cultivation. This crop may be sown early in May for consumption in July, and all through June, July, and August. It is occasionally sown in seed-beds, and transplanted on to prepared stubbles in September, when it will yield a useful crop in early spring. The cultivation is precisely the same as for turnips. Rape should be sown with the drill at the rate of 4 to 5 lb. of seed per acre, in rows about eighteen inches apart, and when the plants are sufficiently advanced (see Turnip Cultivation, Vol. II., p. 373) they should be singled, or at least thinned in the rows, leaving two or three plants together every eight or ten inches. The crop should be horse-hoed about a month after sowing, and should be harrowed several times. This treatment is said to greatly stimulate the growth of the plants. They are ready for use three months after sowing, and a maximum crop will maintain 400 sheep per acre for one week, and may be worth from £3 to £4. Rape is generally eaten by sheep upon the land.

White mustard (*Sinapis alba*) is of comparatively recent introduction as a forage crop. It is much used when from drought or other causes there is a deficiency of winter food. Under such circumstances, as in 1868 and 1870, every endeavour is made to economise turnips in the autumn, and no sooner are the stubbles cleared than they are cultivated or ploughed, and sown with mustard, rape, or even late turnips. Mustard is singularly rapid in its growth, and under favourable conditions will be ready for folding six or seven weeks after sowing. One peck per acre is a sufficient seeding, and almost any description of soil will produce a crop. Mustard will not stand frosts, and must therefore be eaten before winter.

GRAMINACEOUS FORAGE CROPS.

Winter rye (*Secale cereale*) affords the earliest spring food after turnip "greens." It occupies a portion of the land intended for roots, and is followed by swedes or turnips. The cultivation for rye is the same as for vetches. The seed should be drilled at the rate of 3½ bushels per acre, and seven inches apart about the middle of September. It will be ready for folding in April, and while young it affords a wholesome but rather laxative food for sheep. It should be consumed before it shoots into ear, and dry food and mangel-wurzel are recommended to be eaten with it. St. John's day rye is a variety of the above which comes to maturity a fortnight later. Winter barley and winter oats may also be used as forage crops, and will give a continuation of food after the rye is finished.

Italian rye-grass (*Lolium Italicum*) was first brought to this country by Mr. Thomson of Banchory, who obtained some seed at the agricultural show at Munich, about the year 1830. This was grown by the Messrs. Lawson, who subsequently introduced it to the agricultural public. Italian rye-grass far surpasses the English species (*L. perenne*) in luxuriance, and is at once distinguished from it by its broader and more upright leaf, and by its awned seeds. It has been used for purposes of sewage irrigation, and is better adapted for liquid manuring than any other crop. Fifty to seventy tons per acre of grass have in this way been obtained in a single season. In ordinary agriculture it is either sown upon young barley in the same manner as "seeds" (see Rotations, Vol. II., p. 261), or the land is specially prepared by ploughing in manure upon a corn stubble in the winter, cross cultivating in the spring, harrowing, and sowing four bushels of seed per acre with the broadcast barrow, after which the land is rolled or lightly harrowed. Ten tons of grass have been cut six weeks after sowing, but such a result must be looked upon as exceptional. Rye-grass affords several cuttings in the season, and a dressing of nitrate of soda, guano, or liquid manure between each cutting will be repaid by a largely increased yield.

Schræder's brome grass (*Bromus Schrœderi*), although previously known in England, has of late years been brought prominently before the notice of farmers, as likely to supersede Italian rye-grass; but although giving a large bulk of forage, its cultivation does not increase, as its produce is neither so early nor so fine—such, at least, is the opinion of the Messrs. Lawson.

The agricultural grasses include about fifty species. Even a few words upon each of them would extend the limits of the present paper beyond all bounds. In order to at once convey an idea as to the species most usually employed, and the proportions in which they are blended so as to form mixtures, we introduce a table from Messrs. Carter's catalogue, in which suitable mixtures are given for medium soils of alluvial origin, calcareous character and loamy character:—

MIXTURE OF PERMANENT PASTURE GRASSES FOR MEDIUM SOILS.	ALLUVIAL SOILS.		LIMESTONE OR CALCAREOUS SOILS.		LOAMS DERIVED FROM OLD OR NEW RED SANDSTONE.	
	With a Crop.	Without a Crop.	With a Crop.	Without a Crop.	With a Crop.	Without a Crop.
	lb.	lb.	lb.	lb.	lb.	lb.
Anthoxanthum odoratum (*Sweet Vernal*)	1	1	1	1	1	1
Alopecurus pratensis (*Meadow Foxtail*) .	3	3	2	2½	2	2
Arrhonatherum avenaceum (*Large Oat Grass*)	...	...	2	2½	...	...
Trisetum flavescens (*Golden Bristle Grass*)	...	...	2	2	...	...
Dactylis glomerata (*Cocksfoot*) . .	4	4½	3	3	4	4½
Festuca duriuscula (*Hard Fescue*) . .	2	2	2	2	2	2
—— heterophylla ovina (*Sheep's Fescue*)	1½	2	2½	3	2	3
—— loliacea (*Darnel-leaved Fescue*) .	1	1	1	1	1	1
—— pratense (*Meadow Fescue*) . .	2	2	...	...	1	1
Lolium Italicum (*Best Imported Italian Rye Grass*	8	9	6	8	8	9
—— perenne (*Pacey's Perennial Rye Grass*)	4	5	6	7	3	4
Phleum pratense (*Timothy*) . . .	4	4½	2	2½	3	3½
Poa nemoralis (*Wood Meadow Grass*) .	1	1	2	2	1	1
—— trivialis (*Rough-stalked Meadow Gr.*)	1	1	2	2	...	...
Trifolium pratense perenne (*Perennial Red Clover*)	5	6	5	5	5	4
—— repens (*Perennial White Clover*) .	3	3	4	4	3	4
—— hybridum (*Alsike Clover*) . .	1	1	...	...	1	1
Medicago lupulina (*Yellow Trefoil Clover*)	3	2	3	3	3	3
	44½	48	45½	48½	40	44
Per Imperial Acre (best quality) . .	31s.	32s.	31s.	32s.	30s.	31s.
Second quality	20s. to 26s. per acre.					

In sowing grass seeds for permanent pasture care must be taken to have the land in good condition, and clean—*i.e.*, free from weeds. They are most generally sown upon young barley or wheat, in April or early May. The surface must be rolled smooth, and the seeds will be best distributed with a seed barrow, and brush-harrowed in.

Mixtures for one, two, or three years are much simpler, and are formed as follows:—

	For 1 Year's Hay and Pasture.		For 1 Year's Hay and 1 Year's Pasture	For 1 Year's Hay and 2 Years' Pasture
	No. 1. lb.	No. 2. lb.	lb.	lb.
Trifolum pratense	14	8	6	4
T. repens	...	2	4	4
T. hybridum	2	2	2	3
Medicago lupulina	...	4	4	4
Lolium Italicum	18	18	9	9
—— perenne	9	9	18	18
Phleum pratense	...	2	2	2
Dactylis glomerata	2	2	2	2

Such mixtures may be varied to suit the peculiarities of soil and climate to an indefinite extent. Pastures for alternate husbandry are sown as in the case of permanent pasture.

Among other plants which are grown to a limited extent, or have been recommended to the notice of farmers, are the following:—Broom (*Cytisus scoparius*), very rarely used as an addition to sheep pastures; buckwheat (*Polygonum fagopyrum*), principally used for pheasant feeding; burnet (*Poterium sanguisorba*), sown to some extent on high chalky lands instead of clover. Chicory (*Cichorium intybus*) might be more extensively grown with advantage. Comfrey (*Symphytum officinale*) and prickly comfrey (*S. asperrimum*) have recently received attention as available plants for forage. Spurry (*Spergula arvensis*) is used on the Continent as a winter food for sheep, and is sown for this purpose on the stubbles. Yarrow or Mill-foil (*Achillea millifolium*) is a good addition to mixture of pastures. Plantain (*Plantago lanceolata*) is similarly used, as is also field parsley (*Petroselinum sativum*). White lupins (*Lupinus albus*) are occasionally sown on light sandy soils for forage, and for ploughing in as green manure. Chinese sugar-cane (*Holcus saccharatus*) is cultivated a good deal in the south of France, and to a very limited extent in parts of the south of England. Numerous other plants have been suggested by sanguine agriculturists and enterprising seedsmen, but restricted space compels us to desist from further lengthening our list with names which exert so small an interest on the agriculture of our country.

SHIP-BUILDING.—III.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

ELEMENTARY REMARKS ON THE STRENGTH AND STRAINS OF SHIPS (*continued*).

NEXT in importance to longitudinal strains are those tending to cause alterations in the transverse forms of ships, and some attention must be given to them in order to understand their causes and possible effects.

The transverse strains experienced by a ship floating in still water are not usually severe, and only become noteworthy when very heavy weights are concentrated upon, or near, the sides of the vessel. In an iron-clad ship, for example, the weight of the armour-plates secured to the sides is very great; and if we consider, say, the middle portion of the length, where the ship's breadth is nearly at its maximum, it will be evident that there exists a condition of strain similar to that shown in Fig. 2 (Vol. II., p. 401). The whole weight (w) of one side of the ship will act downwards in a line (indicated by the arrow) further away from the centre of the ship than the line of action of the total buoyancy (w) of that side, supposing for the sake of simplicity the weight to equal the buoyancy. Consequently a "couple" is brought into action on each side of the ship, and its tendency is obviously to cause a change of form in the cross-section. Even in the most extreme cases, however, this bending moment cannot be of very large amount when the vessel is afloat; but supposing her to take the ground, and to be supported on her keel only, it would be very much increased, for the line of action of the upward pressure would then be removed to the middle line of the ship, and be much more distant from the line of action of the weight w.

In addition to these vertical forces tending to changes in the transverse form, it is necessary to consider the horizontal forces, due to the pressure of the water on the sides of a ship afloat. The direct tendency of this pressure on each side is obviously to bring the two sides of the vessel more closely together, thus producing a change in form, which must be resisted by the transverse strength of the hull. For a ship floating upright, or in an inclined position, in still water this pressure and its bending effect can be found without much difficulty.

These are merely statical strains, the ship in each case being supposed at rest, and consequently they cannot be compared in intensity with the dynamical strains incidental to rolling motions when the ship is at sea. Under these circumstances it is by no means unusual to find ships, particularly wood ships, actually undergoing changes of transverse form, and in many cases the "working" of the various parts has caused serious damage. Nor is this to be wondered at, considering that the vessel would move rapidly from side to side, passing several times per minute, it may be, from a position like that indicated in Fig. 3 (page 401) to one of as great inclination on the opposite side, and necessarily having her motion checked and reversed rapidly. Here again we meet with a case which foils accurate calculation of the intensity of the straining forces, and permits only of approximate estimates being made. Here also experience comes to the aid of the ship-builder, who has a knowledge of the accidents that have befallen ill-constructed vessels, and is thus enabled to provide sufficient strength in the parts most tried.

For our present purpose it will suffice to say that in resisting these strains the transverse sections of ships (such as are illustrated by Figs. 2 and 3) must act more or less like hoop-shaped girders. The most critical parts in such sections are obviously at the junctions of the beams and the frames (*a*, *a* and *b*, *b*, in Fig. 3), and near the turn of the bilges (*c*, *c*); and observation confirms the necessity for providing special strength thereat. The maintenance of transverse form is also much aided by efficient pillars being fitted in the hold and between the decks. Transverse bulkheads also help considerably to this end, especially in iron and composite ships, where their numbers are often so considerable as to practically prevent change of form in the transverse sense.

Supposing provision to have been made for both of these principal strains—the longitudinal and the transverse—there still remains the consideration of *local* strains and the means of meeting them. Having already said something on this point, only a few remarks need be added in illustration of its importance. In many places weights are concentrated in short lengths of the ship, especially if she be a steamer: to support such weights, and to distribute the load over portions of the hull not directly beneath, or "in wake" of them, "bearers" must be fitted. Where the masts are to be supported "steps" have to be built, to bear and to distribute the downward "thrust." The deck-beams also must be made capable of bearing the weights to be put upon them; the requisite strength of bottom for taking the ground should be provided; and in many other instances the ship-builder has to exercise similar caution. In short, this part of the work is of considerable importance, although subordinate to the main features of the construction, and as it is left more completely in the hands of the ship-builder, it demands the greater attention from him, in order to make special and indispensable arrangements contribute as much as possible to the structural strength.

To a very large extent this is also true of the minor details of the construction, and as a case in point we may refer to the bulkheads or partitions built in the holds of ships to subdivide the space according to the requirements for accommodation and stowage. It is possible, and in well-built ships is actually the case, to add considerably to the vessel's strength without using a much greater weight of material, by turning such partitions into more or less rigid girders, especially when they run longitudinally, as many of them do. For example, in steam-ships there are often coal-bunkers at the sides, the interior boundaries of which are formed of thin iron plating, which must be stiffened to some extent in order to bear the weight of the coal: by the simplest arrangement possible these iron bulkheads can be converted into valuable stiffeners to the structure of the ship at a part where considerable strength is required. It is needless to multiply illustrations, but we must add that in iron ships this principle of utilising the partitions, etc. (fitted necessarily and primarily for stowing the hold), as a means of gaining structural strength, can be best applied; and there can be no doubt that at the present time there is considerable scope for improvement in this direction.

THE COMPARATIVE FITNESS OF WOOD AND IRON FOR SHIP-BUILDING.

Closely allied to the subjects we have just been considering, stands the question of the suitability of the materials commonly used by the ship-builder, and the facilities which they afford for carrying out in practice the principles of construction that have been sketched. Until fifty years ago there would, as we have said, have been question of one material only, wood; but now iron occupies the first place, and the following remarks will probably throw some light upon the causes of its rapid replacement of wood. It is not our intention here to describe the various kinds of timber used in wood ships, or to distinguish between different qualities of iron; but rather to take for granted that in both classes of ships the best materials procurable are employed, and then to examine their relative advantages from a structural point of view.

A merely casual glance might lead one to believe that because iron is *stronger* than wood, it is also superior for ship-building: but this is by no means a complete view of the question. The ship-builder has to consider not only the strength, but also the weight of the material he uses; and it is a matter of fact that, *weight for weight*, a solid bar or beam of wood of rectangular section is in some respects stronger than a similar bar of iron. The latter would bear, say, a tensile strain of 20 or 22 tons to the square inch of sectional area, while the wood would only bear 5 or 6 tons: but on the other hand the iron would weigh, say, 480 lb. to the cubic foot, while the wood would only weigh about 60 or 65 lb. This merely superficial view of the matter, therefore, will not do.

Looking more closely into the characteristics of wood and iron, one sees that there is a fundamental difference between the two materials. The wood is necessarily used in massive solid timbers, the sectional forms of which are more or less nearly rectangular; whereas the iron can be procured with an almost endless variety of sectional forms, and is but rarely used in masses having great thickness as well as breadth. No simpler illustration of our meaning could well be given than that in Fig. 5, where three sections of beams are shown, two of iron, and one of wood (marked 3). The wood beam is of rectangular sectional form, and almost necessarily so; but the iron beams are "flanged" in just the way that science teaches to be the best possible form for resisting bending strains. The upper and lower parts of a bent beam are necessarily subject to the greatest strains, while the parts lying between them are comparatively unstrained. Consequently the best form of section is that which throws a large amount of material into "flanges" at the upper and lower parts, leaving a thin web between, as is done in the iron beams. No practical shipwright would for a moment dream of imitating this sectional form in wood beams, because the very nature of the material forbids the attempt, and it could only lead to failure. Hence we see that the first principle of construction—viz., to dispose the material so that its amount shall be everywhere proportioned to the strain it has to bear—can be much more nearly fulfilled in iron beams than in wood.

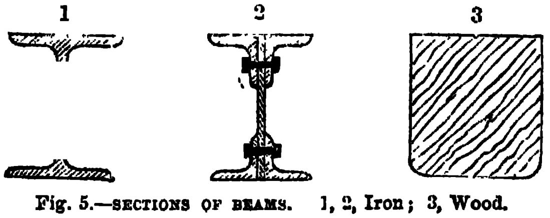


Fig. 5.—SECTIONS OF BEAMS. 1, 2, Iron; 3, Wood.

What has been shown to be true in this simple case is true also in very many other parts of a ship's structure; for instance, in the ribs, which are formed in an iron vessel of comparatively light angle-irons, while in a wood vessel they consist of massive timbers. The grand result of this difference is that in using wood the builder is frequently compelled to place a large weight of material in parts where it is not needed, because he is restricted to the *solid* sectional form; whereas the iron can be either rolled to whatever sectional forms may appear desirable, or easily combined in such a fashion as to arrive at those forms. Before Cort's great invention of *rolling* was introduced no such facilities were available, and even plates of wrought iron were only procured with difficulty by hammering them out; but when once this idea had taken a practical shape, and the path was marked out, progress became rapid. The strides made in this country in the manufacture of iron during the last twenty years have been particularly noteworthy, and even in the last ten years advances have been made which probably surpass all that had been done previously. Armour plates 18 or 20 inches thick, weighing many tons, are now produced, and the skill thus manifested is applied in other directions with no less profit. Let us not forget, however, that all this progress has been rendered possible by an invention of the simplest character, made by a man without pretensions to great scientific acquirements. Cort reaped no great reward, it is true, but he conferred a lasting benefit of immense value upon his country and the world at large, and his name should be held in honour.

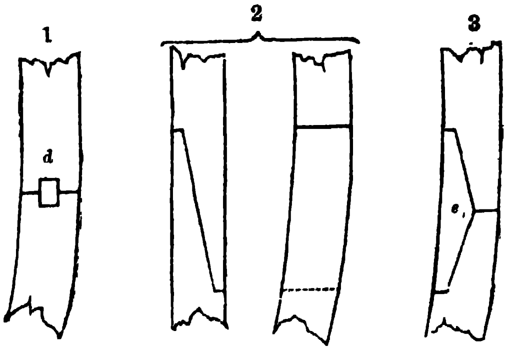


Fig. 6.—MODES OF CONNECTING TIMBERS OF FRAMES.

Passing on, we will next compare the *connections* of the various parts that can be made in wood and in iron ships, a subject of considerable importance; and here one cannot fail to remark the wonderful contrast between the capabilities of the two materials. It has been pointed out that the various longitudinal pieces in the hull of the ship ought to be capable of resisting both tensile and compressive strains, and this fact must be borne in mind here, seeing that it applies with more or less force to transverse framing also. In Figs. 6, 7, and 8 are represented a few of the principal methods of connecting adjacent pieces in the hull of a wood ship, and it will at once appear that no small amount of care and good workmanship are required to carry some of them into practice. The chief difficulty to be overcome in such connections is obviously to make the joint capable of bearing a *tensile* strain, for a plain "butt"—where the ends of the adjacent pieces are cut off square and fitted together—will answer every purpose under a compressive strain, since that tends simply to make the joint closer.

Taking the sketches in order, we first have three modes of connecting the timbers of frames in wood ships. That marked 1 shows what is termed a "plain butt" joint, the only connection between the timbers being formed by the dowel *d*, which is a cylindrical plug of hard wood driven tightly into holes cut out of the ends of the timbers. This connection obviously has little or no strength to resist strains tending to "open" the butt and separate the timbers; but in fairness it should be noticed that the transverse frames are not as a rule liable to severe strains having such a tendency. The plan marked 2 shows two views of a "plain" or "plane" scarf, and needs no explanation beyond the statement that the overlapping timber-ends are usually secured together by dowels in the bearing surfaces as well as by through-bolts. This plan is evidently possessed of considerable power for resisting tensile strains, and it is used in the few parts of the framing where those strains may be expected to be considerable—for instance, in the neighbourhood of the masts, where the shrouds are secured to the upper works of the ship. The plan marked 3 is now used only in building merchant ships (instead of 1); *e* is a "chock" of wood fitted into recesses cut in the timber-ends, and is secured to both by bolts or "tree-nails" (*i.e.* long wooden pegs), thus forming a sort of strap over the butt, and giving some power of resistance to tensile strains. In fact, in the olden times of wood ship-building the mode of connection illustrated by 3 was, in principle, a very common one for securing pieces subject to considerable tensile strains, only the chocks were made much longer, in order to distribute the fastenings over a larger area and give greater strength. We should add that the plain scarf (2) is still very largely employed in connecting pieces running longitudinally in wood ships: for example, the keelson, and the shelf-pieces underneath the ends of the deck-beams.

The remaining examples of the connections used in wood ships are of a more elaborate character, and are used only in parts where the greatest possible amount of resistance to tensile strains is required. The "scarf with tabling" in Fig. 7 is shown in elevation, plan, and section, and will be seen to constitute a strong connection; but it evidently necessitates great care and expense for workmanship. This scarf is, in fact, a plain scarf, plus the "tabling" (marked *t* in the sketch); the latter consisting of raised tenons fitting into corresponding mortises, as is clearly shown by the section at *a*, *a*. For one-half the length of the scarf the tenon is formed on one of the pieces, and for the other half on the other; the mortises being situated, of course, conversely in order to receive them. It will be noticed that the tenon is formed on the thinner half of the scarf in each piece, and that its breadth is about one-third that of the pieces joined. This kind of scarf is used for the keels of wood ships, and being fastened by numerous bolts (six or eight in a large ship), it forms a very strong connection.

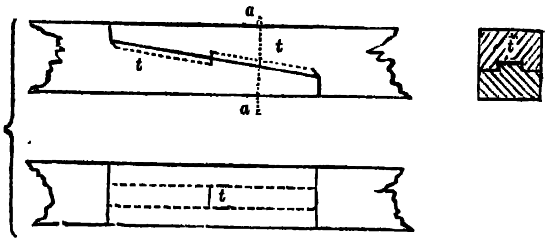


Fig. 7.—SCARF WITH TABLING.

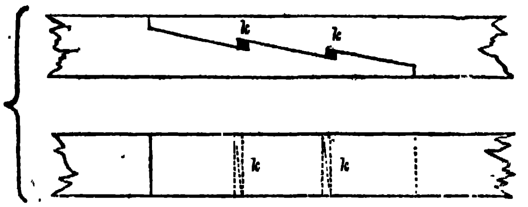


Fig. 8.—HOOK SCARF WITH KEYS.

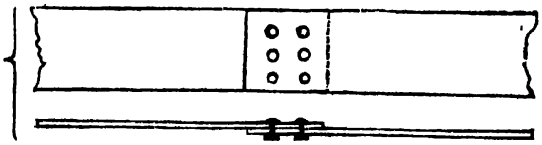


Fig. 9.—IRON PLATES WITH LAP JOINT.

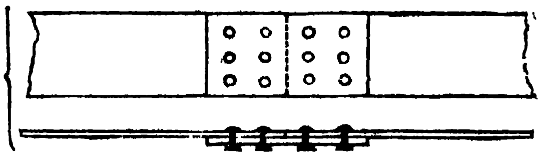


Fig. 10.—IRON PLATES WITH FLUSH JOINT.

No less elaborate is the "hook-scarf with keys" shown beneath it, a connection which is commonly used in putting together the pieces of the beams in wood ships. When formed and fitted, wedge-shaped iron keys (marked *k*, *k*) are driven into spaces left for this purpose at the shoulders of the "hooked" surfaces, and the scarf is thus tightened or "set up." In this case also the scarf is fastened by means of several through-bolts and tree-nails, which have been omitted in the sketch for the sake of clearness.

On a review of all these examples of the most approved connections used in wood ships, it becomes obvious that great difficulty has been experienced in rendering them efficient, and that a fair resistance to tensile strains can only be secured by elaborate and expensive joints. Turning to iron ships, an entirely opposite state of things is found; for in them the most simple and inexpensive connections can be made efficient against tensile as well as compressive strains. Two illustrations of this are given in Figs. 9, 10; the first showing a joint where the plates are "lapped" at the ends and riveted, and the second a joint where the plates are "butted," and connected by means of a "butt-strap." One of these two simple plans is applied in almost every case where adjacent pieces have to be joined in an iron ship; the only exceptions being those where thick bars, such as are often used for keels in iron merchant ships, are connected by means of plain scarfs fastened by through-rivets.

Moreover, *welding* can be used to a considerable extent in connecting the parts of iron ships, if it is considered desirable; and those parts themselves can be procured in sizes and bent to forms such as render fewer joints necessary than are required in wood ships. For example, one "rib" or frame in a wood ship of any size is always made up of several pieces connected together in one or other of the modes shown in Figs. 5, 6, and 7; and it is impossible to follow any other course, seeing that timbers of the sizes and curvatures required for the frames cannot be procured in great lengths. On the other hand, it is a very common thing to find the angle-irons forming the frames of iron ships made in one length from keel to gunwale, and any amount of curvature required can be given them. Or to take another illustration: instead of having the beams of a large vessel made up of two or three pieces connected by hooked scarfs, as is the case in wood ships, it is the common practice in iron ships either to have the beams rolled in one length, or else formed of pieces welded or riveted together, the former plan being that which finds most favour now that the facilities for manufacturing iron of the sections required are so greatly increased.

MINING AND QUARRYING.—XIV.

BY GEORGE GLADSTONE, F.C.S.

STEEL (*continued*).

SPIEGELEISEN — BESSEMER STEEL — HEATON'S PROCESS — MECHANICAL PROPERTIES OF STEEL—ECONOMICAL USES —INCREASE OF MAKE.

MORE than once in the preceding papers on iron and steel has the advantage of using manganese been touched upon; but this part of the subject would be incomplete were we to omit referring more particularly to *spiegeleisen*, which is a peculiar description of pig iron made largely in Germany, and bearing a German name which translated into English means "specular iron." It is made from the spathose carbonates which are common in that country, and is highly crystalline, showing large bright cleavage planes, which have given rise to its distinctive name. In chemical composition it is very different from any of the English pig irons which have been previously spoken of, the following being the actual analysis of an ordinary sample:—

Iron . . .	88·961	Nitrogen . .	1·200
Carbon . . .	5·440	Copper . .	0·166
Manganese . .	4·003	Tin . . .	0·116
Silicon	0·179		

Here, then, we have a pig iron rich both in carbon and manganese, and very free from the noxious ingredients which have so constantly followed us in the operations of iron-making. One of the principal reasons for their absence is that the spiegeleisen is smelted with charcoal, and not with coke.

The quantity of manganese, however, varies considerably, and many specimens will give a much larger proportion than that recorded above.

It scarcely needs to be pointed out how convenient it would be to add some spiegeleisen in either of the operations described in the last article for making steel, as it would just supply the ingredients wanted for the purpose, and at the same time, by its freedom from impurities, reduce the relative proportions of those objectionable ingredients in the resulting metal. It is accordingly largely used for such purposes.

An alloy of iron and manganese, called ferro-manganese, is now prepared in Glasgow for the special use of the makers of steel, by reducing, upon the open hearth of a Siemens' furnace, a mixture of the carbonate of manganese and oxide of iron in presence of an excess of carbon by means of a reducing flame. The furnace-bottom is of ground coke, consolidated and baked up in the form of a large crucible. The charge of the salts of iron and manganese, finely ground and mixed with powdered charcoal or coke, is heated to redness for several hours. It thus becomes converted into a metallic sponge, which contains the reduced metals from both the ingredients, and which is then run down to a solid by raising the temperature to a white heat. The alloy contains from 20 to 30 per cent. of manganese. A German manufacturer has succeeded in making an alloy which contains a very much larger proportion.

We must now turn our attention to what is called the Bessemer process of making steel, in which either crude or refined pig is the article operated upon. The apparatus used is precisely the same as that described under this name in Article XI. for puddling iron, and all that is necessary to produce steel is to stop the operation and pour out the limpid metal into the moulds after about ten minutes' boiling. By that time the carbon will not be so far exhausted as to have converted the metal into a malleable iron. In practice, however, it is difficult to judge with sufficient exactitude when the decarbonisation of the pig iron has gone far enough; and there was always considerable uncertainty as to the quality of the steel produced, so far as the per-centage of carbon is concerned. It has been found more desirable, therefore, to let the operation take its course until the carbon is reduced to a minimum, and then to add a certain quantity of spiegeleisen the analysis of which is known, and from which the per-centage of carbon in the resulting steel can be estimated with sufficient accuracy.

Another process essentially different from Bessemer's, though perhaps partly suggested by his, is that called after its inventor, Mr. Heaton, and which has only recently been introduced. Pig iron is used, which is melted with coke in the ordinary way, in a common cupola furnace; from this it is drawn off into a ladle worked by a crane, and transferred to the converter. This, of which Fig. 3 is a drawing, is a wrought-iron pot, lined with fire-bricks and refractory clay, which runs upon wheels, the chimney from the line A upwards being a fixture supported by the columns, B B. In the bottom, C, of the convertor is introduced a charge of crude nitrate of soda, one-tenth in weight of the iron to be operated upon. Immediately upon the soda is laid a perforated iron plate, which is firmly worked into the clay that forms the shoulders, D D. The converter, with its contents, is wheeled under the open mouth of the chimney, and securely fixed in its place; and then the molten iron from the cupola is poured in at the hopper E, the door of which is at once closed.

For the first two minutes all is quiet; then some nitrous flames are seen to escape from the chimney; after the lapse of five or six minutes a violent deflagration occurs, accompanied with a loud roaring noise, and a burst of brilliant yellow flame from the top of the funnel, showing that the reaction is at its height. This lasts for about five minutes, and then suddenly subsides. The whole operation is then complete, the converter is removed, and the contents poured out upon the floor, when cold water is thrown upon the metal to render it brittle. It is then broken up into lumps, and re-heated, forged, and rolled; or the "cake steel," as the broken pieces after being shingled are called, is re-melted in crucibles with the addition of about 3½ per cent. of spiegeleisen, and poured into ingot moulds, which produces a steel of superior quality.

The following analyses, made by Professor Miller, of the pig iron used, the resulting crude steel, and the slag separated, will show that the product is essentially different from what would have been yielded under the Bessemer process; and that Heaton's plan is applicable to irons containing large quantities of sulphur and phosphorus.

	Pig Iron used.	Crude Steel made.
Carbon	2·830	1·800
Silicon with a little titanium	2·950	0·266
Sulphur	0·113	0·018
Phosphorus	1·455	0·298
Arsenic	0·041	0·039
Manganese	0·318	0·090
Calcium	—	0·319
Sodium	—	0·144
Iron (by difference)	92·293	97·026
	100·000	100·000

In comparing the constituent elements it will be seen that a great reduction is made in the carbon, silicon, sulphur, phosphorus, and manganese existing in the pig iron. The analysis of the slag which was separated gave—

Sand	47·3
Silica in combination	6·1
Phosphoric acid	6·8
Sulphuric acid	1·1
Iron (a good deal of it as metal)	12·6
Soda and lime	26·1
	100·0

The presence of calcium in the metal produced was due to the use of lime at the time that Professor Miller made his analysis, but that has since been dispensed with. From the proportion of iron in the slag, it would appear that there is a considerable loss, but it must be borne in mind that 12·6 per cent. in the slag would not amount to more than 3 per cent. in the pig iron used. Under the tests which will be described directly, this steel will compare most favourably with that made by the other processes.

It must be borne in mind that though bearing the same name, and having such a per-centage of carbon in combination with the iron as justifies the use of the term, the steel produced by all these various means is very different from that made in Sheffield by the cementation process. It supplies, however, a want which was becoming increasingly felt, of something that should take an intermediate place between iron and the very expensive steel. As such, its use is rapidly extending; and in order to show how it may be employed to advantage, we must refer to the elaborate series of experiments which have been made by Fairbairn of Manchester on the mechanical properties of steel.

As a civil engineer, his object was to ascertain how far the cheaper kinds of steel especially were suited to the purposes of construction; and for this purpose it was necessary to determine its relative strength as compared with iron, and also whether it could be produced of sufficient uniformity of character to enable the builder to rely upon it. Upon this latter point, a most essential one, his final verdict is, that the homogeneity of its structure can be depended upon; and we may therefore proceed to consider the nature of the tests to which he submitted the metal.

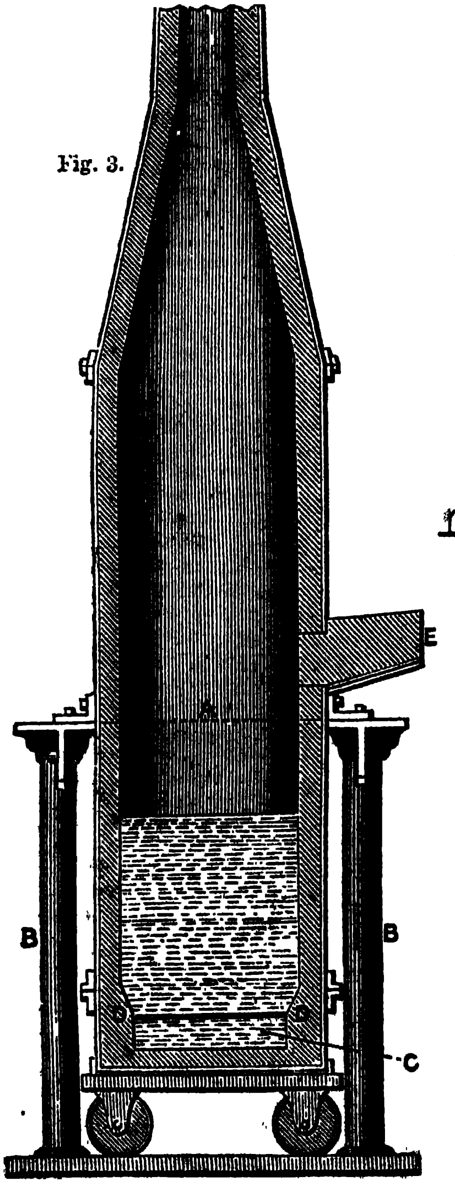
These were threefold. Each of the specimens were submitted to transverse, tensile, and compressive strains; the first of these being by far the most important. The apparatus used for this purpose is figured in Figs. 4 and 5. It consisted of a frame, A, to which were bolted two iron brackets, B B, on which the steel bars to be tested were laid. The space between the brackets was exactly 4½ feet. Immediately over the centre of the bar E, at a point equidistant between the supports, hung the scale D, which could be raised at pleasure from resting on the bar, by means of the wheel and screw C. The weights were placed in the scale, 56 pounds at a time; after each weight was laid on, the deflections were taken, and then the screw C was turned so as to raise the scale and relieve the bar of its load, thus enabling the experimenter to ascertain the effect of the load upon the bar, and to register the permanent set.

The general results arrived at were, that in resistance to a transverse strain the best of this description of steel has nearly 3½ times the strength of a bar of wrought iron of the same dimensions; and comparing, therefore, the relative prices of iron and steel, estimated at £7 and £12 respectively, there would be a saving of 25 per cent. in using the more costly material. The second series of experiments showed that in respect of tenacity the steel was nearly double the strength; which, at the same prices, would also leave a small balance in favour of this metal.

The resistance to compression was found to be equal to about 5½ times that of extension, which suggested the conclusion that the most economical form of a steel bar undergoing transverse strain would be a bar with double flanges, having the area of the bottom flange about double that of the top one. For the sake of comparison, however, a steel girder of the ordinary form was taken, the dimensions of which are shown in the cross-section (Fig. 6); the length between the supports was 13·9 feet. The steel was made on the Bessemer principle at the Barrow hæmatite works. The girder was loaded with 18 tons without breaking, but on adding 2 cwt. more it broke by tension through the angle-iron of the bottom flange, as shown in Fig. 7. This experiment, therefore, not only corroborated the conclusion previously arrived at as to the best form of a steel girder; but also showed the comparative strength of a steel one of the ordinary form, as a wrought-iron girder of the same dimensions would break on the application of 11 tons 16 cwt.

It will be readily inferred from these data that this description of steel is coming into competition with iron for the ordinary purposes of construction; but there are one or two special applications which deserve notice. The first of these is, as rails. Where there is a very large traffic, the wear and tear of the best wrought-iron railway bars is very great, involving the cost, inconvenience, and danger to the workmen, of frequently turning and replacing them. In process of time they split, and large pieces peel off, until they are no longer safe. By making the rails of cast steel, however, the tendency to split is obviated, and the metal is so hard that the wearing by simple abrasion is reduced to a minimum. In those portions especially of a railway where the passing of trains to and fro is very constant, the use of these rails is to be recommended on the score of economy, independently of the other great advantages above named.

Fig. 3.



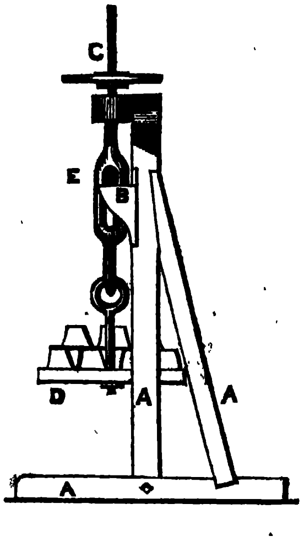


Fig. 5.

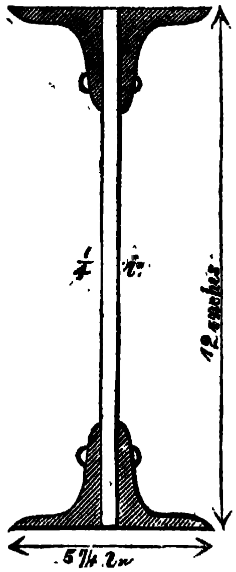


Fig. 6.

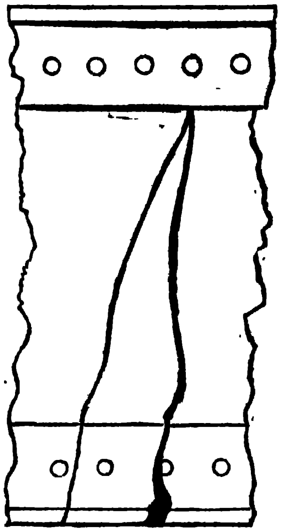


Fig. 7.

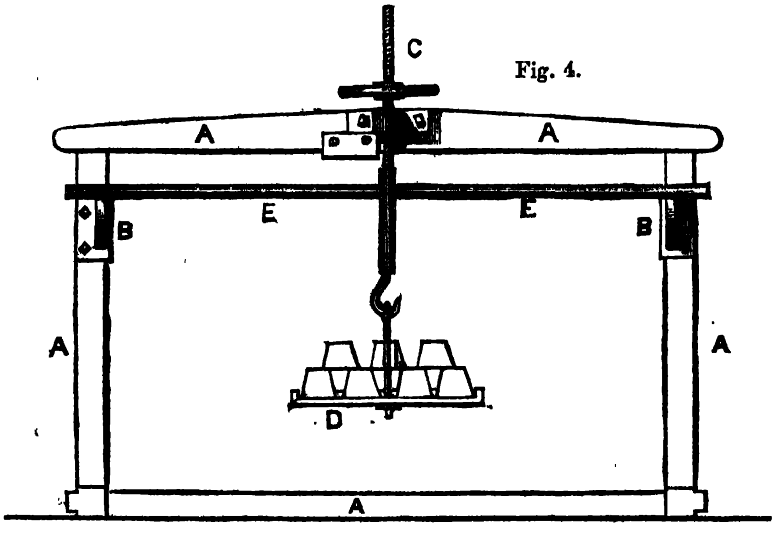


Fig. 4.

Then there is the application of steel to ship-building purposes. Boats made of steel have frequently been taken overland in sections by travellers, and the pieces riveted together in the interior, for the purpose of exploring inland seas, steel being the lightest convenient material which would not be affected by the climate. Its lightness, as compared with iron, is, however, of equal advantage to the general ship-owner, as the displacement of a ship in the water is proportional to her weight; so that according to the number of tons saved in the construction of the vessel, she will be capable of carrying so many more tons of cargo at the same draught of water, and thus earn a larger amount of freight. Besides this there are many rivers and harbours both here and abroad, such as Newhaven and Dieppe, which can only be entered by vessels of light draught, or at certain states of the tide; and into many of these a steel-built vessel could enter at any time, while an iron one of precisely the same size, and built on the same lines, would have to wait outside for the rise of the water. Those only who have experienced the inconvenience of waiting outside a harbour for the rise of the tide, in bad weather, will be able to appreciate this advantage at its full value.

Although, therefore, this manufacture is of comparatively recent introduction, we need not be surprised to find it rapidly growing into favour; that many of the fast steamers round our coasts are already built of steel; and that there are works specially devoted to the manufacture of this article, such as that at Barrow, where 60,000 tons of steel rails, tires, plates, etc., are turned out annually.

FISH CULTURE.—II.

BY GREVILLE FENNELL.

EARLY WRITERS ON FISH CULTURE—FRESH-WATER FISH FARMING—CAUSES OF STERILITY OF FRESH-WATER STREAMS—PROTECTION OF FISHERIES AT HOME AND ABROAD.

Fig. 11.—ADULT SALMON.

MANY works were written during the earlier times in reference to fish culture, for then, during the predominance of the Roman Catholic religion, fish was a necessary article of diet, and every bit of water, natural or artificial, was at a premium, and in consequence made the most of by systematic if not scientific treatment. The Honourable Roger North's work, published in 1713, is notably a great authority on this subject. He descants upon the situation and disposition of the principal waters, of the manner of the making and raising pond-heads, their dimensions, and how to secure their banks; of sluices, of auxiliary waters, stews, moats to lay the great waters dry, of the breeding of fish and stocking waters, of feeding fish, etc. But as this and similar discourses were written at a period when water, as we have said, was extremely coveted, and not as now left to take care of itself, we need not do more than make a passing remark on these authors. Roger North writes, "The string of ponds in Hyde Park are admirably disposed in this respect," which tells us that the Serpentine was not formerly, as now, a continuous sheet of water. He is an advocate for moats, although he thinks they kill more inhabitants than they serve to protect, "the stench and filth from them when laid dry being insupportable." He says, "Now as for your stews, the care of feeding is best entrusted to a butler or a gardener, who are or should be always at home, because the constancy or regularity of serving the fish conduce very much to their well eating and thriving, for they will expect their meat as duly as horses, and appetite in any creature wastes by disappointment. Any sort of grain is good to feed with, especially malt coarse ground; pease boiled a turn or two are as good as any other grain; the grains after a brewing, while they are good and sweet, are very proper; but one bushel of malt not brewed will go as far as two of grains. The chippings of bread and orts of a table, steeped in tap-droppings of good strong ale, are very good food for carps. Of these, the quantity of two quarts to thirty table-carps every day is sufficient; and to feed morning and evening is better than once a day only." But who thinks of feeding their carp now, unless it is those who are supported by voluntary contributions in the marble basins of Hampton Court? The profit would be still the same if not greater than in former years, and there is an obvious tendency to return to a practice which gave those commercial advantages which water-owners formerly derived from judiciously improving the breed and breeding of fresh-water fish, and the large amount of good they did to the community by the great quantity of wholesome food they brought into the markets of both town and country. Jews are at present the principal purchasers of fresh-water fish, and they are not indifferent to their culture, and would doubtless assist in supporting any well-arranged system for their increase and constant supply.

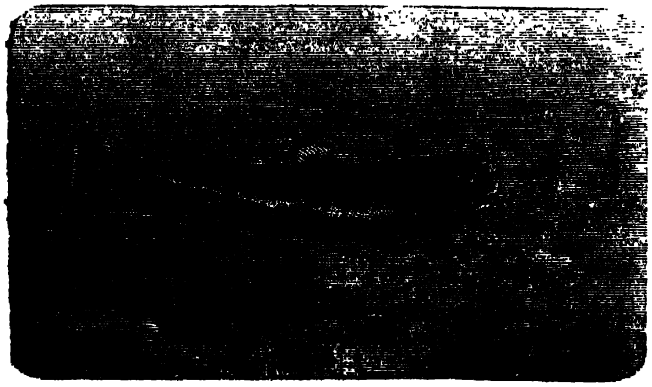


Fig. 9.—YOUNG SALMON.

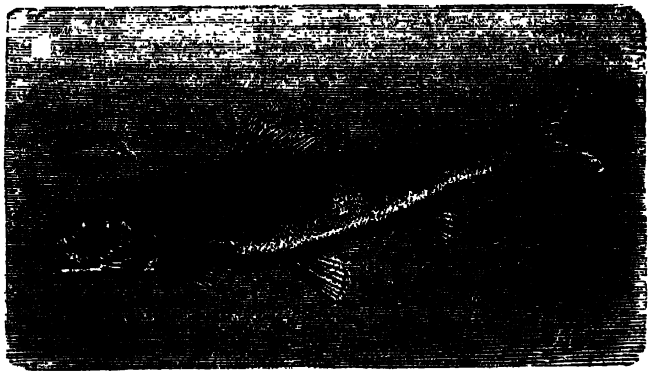


Fig. 10.—SALMON OR PARR, A YEAR OLD.

The pursuit of fish farming is, however, not quite extinct in this country, although we question whether the stock is not in general left to itself to increase and to multiply and find its own food. The last which we glean of the custom is from G. A. Cooke, who speaks of the numerous fish ponds in Sussex as being of considerable consequence. "The ponds," says he, "in the wealds are innumerable. The mill-ponds also raise large quantities of fish; they are an object of sale. A Mr. Fenn of London was once the sole monopoliser of all the fish sold in Sussex. Carp is the chief stock, but tench, perch, eels, and pike are raised. Mr. Milward has drawn carp from his marl-pits, 25 lb. a brace, and two inches of fat upon them, as he fed them with peas. The usual season for drawing the ponds is either autumn or spring; the sale is regulated by measure, from the eye to the fork of the tail. At 12 inches, carp are worth 50s. to £5 the hundred, of course, to sell again; at 15 inches £6, and at 18 inches £8 or £9. The late Lord Egremont had several noble ponds for breeding, and others for fattening, with streams running through them. They were fished every third year, and the best reserved for the stews."

The establishment of railways and the facile and cheap carriage of salt-water fish into the interior of the country, where at one time a mackerel or sole was a luxury, has tended much to the neglect of fish-farming as a producer of food; but the rapid spread of the love for angling promises to restore most of our neglected waters to that condition from which they have fallen. To show, indeed, what a subject of interest angling has of late years become, we need only instance the fact that a comparatively few years ago, there existed but one journal, that of *Bell's Life in London*, which gave especial attention to the subject, and that now every newspaper of ordinary intelligence opens its pages to its doings, comments freely upon the pursuit, and devotes leading articles in sensational and encomiastic language in praise of its healthful tendencies and innocent delights. Moreover, senators retire with the rod to the torrent-side, have their achievements as duly chronicled as the recess speeches of other members of the Legislature; and the professional man no longer conceals his tackle as he makes his way out of town, but rather parades it outside cab or on railway platform, as the welcome companion of his rambles rather than an evidence of idleness; and consequently those rods which under the guise of walking-sticks had once such a sale, are now scarcely to be obtained, much less hypocritically used and patronised by those who were accustomed to disguise part of their purpose in their errand after health.

Perhaps the disgraceful state of non-cultivation is evidenced by the shameful manner in which the Norfolk broads and rivers are netted during the spawning time, with only the paltry excuse that the fish are wanted as bait for salt-water fisheries or for the pigs. Mr. Alexander Russel, in his excellent work upon "The Salmon," says, "Water as well as land was designed to provide food for man; and not only is there no reason why man should destroy the one source, while he is laboriously fostering the other, but there is no obstacle in Nature to water being, like land, rendered immensely more productive by the appliances of art and skill. The fact, however, that Nature, for whatever ends, has made the water more prolific than the land, is no reason at all why man should reduce the water to sterility while making such efforts to maintain and increase the fertility of the land—nay, should even destroy the water with what might further enrich the land. For it is a fact that, whilst the utmost that skill, capital, and labour could do, has been done for the land, not only has nothing been done *for* the water, but a great deal has been done against it, as especially enormous mischief is done by materials that should be kept to give fertility to the land, being sent away to inflict sterility upon the waters."

"The main cause why all fresh-water streams become sterile in the end, if not carefully tended, is simple enough; namely, all the smaller streams form the sewers of the adjacent country, and fall into the larger rivers, and the latter again act as the sewers of the towns and of the kingdom, and are carriers of their congregated impurities finally to the sea. The increasing population of human beings charges the rivers every day with more and more foul matters, the refuse of towns and the agrarian districts passing into them, and hence the destruction of the spawn, egg, or ova of fish, *but not of the fish when once brought into life.*" Had Mr. Boccius lived till 1871, he would have expunged the words written in 1848, which we place in italics, the contrary of which he seems half prepared to admit when he adds: "One cause of this I shall explain chemically. Water is composed of one volume of oxygen gas and two volumes of hydrogen gas. No life can be sustained without oxygen, let it be animal or vegetable; consequently, when water becomes thickened by other matters, a new compound is introduced, which produces a new chemical action; and this is the cause why all rivers and streams eventually become barren; for the following is the result of such a condition of waters, which it is an abuse of language any longer to call fresh. The egg of a fish, in production, differs from that of other animals, as the absorption of the spermatic fluids does not take place till it has passed from the parent, and is then left on its bed, hill, or weed, according to the description of the fish, until the period of incubation has arrived; but in the meantime, should the water become foul and change its character, then the alluvial deposit in the water settles down upon the pedicle or neck of the egg, hermetically seals the same, and prevents the oxygen gas (the component part of water) from being absorbed and passing to the embryo, from which cause suffocation takes place, and the egg is, in the common phrase, addled. This may seem strange, but the student of the laws of Nature well knows that oxygen gas is as absolutely necessary to life as it is the slow destroyer of all things. The destruction of the eggs of the trout from the cause just assigned, I have proved to many friends, having shown them thousands in a putrefied state on their own natural hills or breeding grounds; whilst, upon the principles I have to detail of my methods of producing fish, not a single egg is lost."

The above extract calls for two observations we deem of no little importance. The first is the assertion that the sewage has no effect upon the fish when once brought into life, which all subsequent experiments have proved to the contrary; indeed, so much so that in the Thames and other rivers, it is now admitted that it is a scandalous waste of money and embryo food to introduce salmon, which Mr. Boccius rightly calls "the superior class and quality of fish," until the waters are in such a state of purity as to be prepared for its maintenance.

As regards sewage, we could show by numberless facts that the aristocratic salmon and trout, and indeed several other fish of cleanly habits, will turn tail at the slightest indication of filth; and it is well known upon salmon rivers, that if the smallest portion of putrid garbage, or even the offal of a lamb, is thrown into the stream, it will turn the course of the passage of the fish, and detain them until the effect of the offensive cause is removed. The conditions being, therefore, at the worst, it would actually better pay us to breed in the Thames for sport the coarser kinds of fish, which are more capable from their nature to battle for a while with the foul state of the waters, than are the more sensitive and refined. "Is it not monstrous," says an indignant ichthyologist, "that we are to listen patiently to the minute instructions of how to keep clean and free from offensive particles the troughs and boxes in which we would breed the salmon and trout, and then to hear that after an education in the strictest sanitary *school* of cleanliness, we may safely turn them out into rivers where the state of the impurity may be measured by the depth in inches of a slimy mud deposit, and the poisonous character of their flow ascertained by the absence of the wild flowers that once adorned the banks of the stream?" 120,000 trout which Mr. Boccius bred and turned into the Colne would now have had their millions of great-grandchildren (that is, always subject to the maximum of support a water can afford), and the Wandle its beautiful tenants in profusion, if the one great condition of purity had not been neglected or shamelessly ignored. Paper mills, cotton factories, tanneries and chemical works have much to answer for; but until their owners can see that "waste" can be rendered an item of profit, or they are compelled to find other channels than a running stream for the vehicle of what they desire to remove to their neighbour, the pursuit of artificial hatching must be attended with considerable cost, and, what is still of greater consequence to the advance of science, disappointment, which means serious retardation.*

Who, let me ask, ever found salmon, salmon trout, trout or grayling, or indeed barbel or gudgeon in waters with a muddy deposit; and who that knows anything of the subject expects fish to stay in waters thus situated longer than they could possibly help, or else become sick and die? "In order," says Mr. Boccius, "to prove to demonstration the destructive effects of the deposits of a river when its waters become impure, I had a small bond made from the stream, which was well gravelled, and guarded at either end with perforated zinc plates, and the top covered over, so that neither water-fowl nor heron could ravage the hill. It was spawned with more than 10,000 eggs; but notwithstanding the seeming prospects, not more than a dozen fry came forth, the remainder being all addled."

As our object is more of fact than of theory—of what is than what was—we shall not follow fish culture back any great way—indeed, not farther than will serve to introduce the present practices, and render them plain and practical. It may here be remarked, that provided always the waters are kept free from deleterious matters, and unfair deterioration by poachers, etc., their wonderful productiveness in the shape of fish is beyond question. "There is no animal in the world like the fish in its power of multiplying its own species; but fresh waters require care and protection; they must be managed as well as protected, and they must be protected and managed on sound principles, or all rivers and streams running through populous countries will be in no long time wholly depopulated of their finny tribes."[*] This was written by our late friend Mr. Gottlieb Boccius so far ago as 1848, and the consequences in many districts have too surely followed this prophetic and almost unheeded warning. Happily, now most classes are alive to the vital importance of our fisheries, and we need not fear, with the mental resources and indomitable perseverance around us, that so great a slur will be permitted long to remain. The people's healthful food and the people's healthful recreation are now engaging the thoughts of active minds. The direction which such benevolent aspirations must take, cannot otherwise than embrace the hundreds of miles of water which flow over or lie quiet upon the surface of Great Britain, all courting the protective hand of man, either to remove those causes of their barrenness and sterility, or to watch over and develop the countless stores of fish which they are ready and willing to offer us. To show how much legislative interference is needed, we could instance very many lengths of water, from two miles to thirty, which possess every essential requisite for breeding fish, provided they were restored to their former purity and properly protected. Yet these valuable resources are given up year after year to the devastation of the net, which scarcely leaves any fry behind, being replenished again and again from neighbouring preserves, only to be thus annually depleted to the profit of those who neither take part in nor pay for the cost of the production of the stock. Hence the importance of the mesh of the net being fixed by competent authorities after due local inquiry (as every river has its own peculiarities), the object being to catch the adult marketable fish, leaving the younger to keep up the stock—in other words, "a mesh to catch all the sheep and let the lambs through." The produce of Scotch salmon fisheries is valued at £300,000 per annum. The rental of the Tay alone is £17,000 a year, and that of Irish rivers is very considerable. The Norwegian and Swedish fisheries improve their rentals every day, the principal returns being from anglers. But from what we hear of the increase of seine and bag nets in their estuaries, it may not be long before resort will be had to fish culture. Still, with the absence of all pollutions from most of their rivers, it may be long before any serious mischief occurs.

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* See Pollutions in Report of Scotch Fisheries, 1871.

The Rhine runs through Holland, France, Prussia, and Switzerland, and although there may exist a difference of opinion in these countries in regard to national boundaries, there is none in reference to the capabilities of the Rhine as a salmon-producing stream. Consequently the importance of the subject has given rise to a society now in operation at Berlin, under the highest Government officers of the several interests, Der Deutsche Fischeriei Verein, which is about at once to undertake the fish cultivation of this river. There can be little doubt but that the Rhine is capable of producing many thousand pounds worth of fish, if a proper understanding can be arrived at amongst all parties, although the canalising that river, while improving its channel for navigation, has had a deteriorating effect upon its natural basin as a nursery for fish.

The managers of Der Deutsche Fischeriei Verein are in correspondence with the leaders of fish culture in England, as in this art it is now generally acknowledged that this country takes the most forward place in Europe. Indeed, in regard to salmon culture, Great Britain now stands unrivalled. There are thirty-four district boards in England under the acts of 1861 and 1865, who carry out fish culture on a very large scale, regulating nets, fixed engines, ladders, weirs, preventing pollutions, and, above all, giving protection to the fish in the winter time. All the large Scotch rivers are under the management of a board of the most influential people of the country: Ireland also is divided into districts which work under Irish acts of Parliament. In England and Wales, inspectors are appointed to travel about and advise, and report annually to Parliament. There are special commissioners appointed to inquire into law points as to rights of salmon property. In Ireland there are three inspectors, who also issue annual reports. These gentlemen likewise have to watch the oyster and sea fisheries. There are three Scotch commissioners whose duties are more legal than executive, and we learn from the latest report that the Scotch proprietors in the district board are anxious for inspectors to be appointed to carry out provisions of schedules, especially G, as to passage of fish over weirs, and Schedule F, regulation of cruves (fishing traps), gratings, annual close time, meshes of nets, and other details of importance. Sweden, Russia, and Denmark have also inspectors of fisheries, and so also has Canada. America appears, however, but recently to have awoke up to their necessity, and this has been brought about by the announcement that the shad are nearly extinct, and the salmon are being rapidly exterminated by the increasing quantity of saw-dust accumulating in the principal rivers from the water-mills. The states of New York and Boston are taking great pains to open up rivers, and increase the fish by artificial hatching. Mr. Seth Green has done much in the latter direction. His last useful act was to transport shad to the rivers of California. Mr. Andrew Murray, F.L.S., has brought the eggs of the sterlet from Russia, and turned them out in the Shin, under the auspices of his Grace the Duke of Sutherland.[*] Sir Stephen Lakeman has brought over three living specimens of the gold schley, now quite naturalised in this country at Aldermaston Park, near Reading, the seat of Mr. Higford Burr, a zealous and practical naturalist. Sir Stephen Lakeman likewise succeeded in introducing the thunder-fish and the *Silurus glanis* into this park, but the experiment failed, the fish having unaccountably disappeared, but they probably fell a prey to the herons, a colony of which is close by.

We append some excellent illustrations of the salmon in three different stages: (1) the young salmon during the early stage of its existence; (2) the parr, or salmon a year old; and (3) the adult or full-grown salmon.

BRICK AND TILE MAKING.—V.

By Gilbert R. Redgrave.

COPING BRICKS—MOULDED BRICKS—GAUGED BRICKS—TILES—ROOFING AND DRAIN TILES.

Before passing on to the manufacture of tiles, it may be as well if we glance briefly at some of the many descriptions of bricks. These, as may be supposed, are almost endless, and we can only, in the space at our command, refer to a few of the chief of them. Coping bricks are used to surmount walls, and are so shaped as to throw off the water, and provide a slightly overhanging protection to the wall; they are, therefore, generally rounded, or made with a slant or double slant at the top, and should be provided on their under surfaces with a slight groove on each side, in order to form a drip to throw the wet off the wall. They are seldom made for walls more than 14 inches in thickness, and should be one inch wider on each side than the wall—thus, 11 inches for 9-inch brickwork, and 16 inches for a wall 14 inches wide. Moulded bricks are made in every variety for enriched surfaces, and take their names from the shape of the principal moulding on them: arch-bricks are those made in the form of a wedge, in order to serve as voussoirs; splayed bricks, such as have one of their edges canted off, and are employed for set-offs and plinths; compass bricks, used for building circular walls and sewers; channel bricks, for gutters; clinkers, specially made for paving; and bond bricks, which are from 14 to 18 inches in length, and are used to improve the bond of common brickwork. There are also special names in different parts of the country for the various qualities of bricks, with reference to the respective excellence of their manufacture; thus the best, according to the nature of the brick, may be called malms, rubbers, or cutters; the seconds, stocks, or malm stocks, and grizzles; and the inferior and

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[*] The spawn of fish ought to give us some notion of what is lost to us for want of extended protection. The following is from Buckland's "Fish Culture:"—

	Weight of Fish.	*Total No. of Eggs.*
Salmon	20 lb.	17,500
Trout	1 lb.	1,008
Jack	4½ lb.	42,840
Perch	½ lb.	20,592
Roach	¾ lb.	480,480
Smelt	2 oz.	36,652
Lump Fish	2 lb.	116,640
Brill	4 lb.	239,775
Sole	1 lb.	134,446
Herring	½ lb.	19,840
Mackerel	1 lb.	86,120
Turbot	8 lb.	385,200
Cod	20 lb.	4,872,000

[*] Vide *Field Quarterly*, Feb. 1871, page 23.

underburnt kinds, shuffs, sammel or place bricks. Those which are so overburnt and run together as to be quite valueless, are called clinkers or burrs, and are broken up and used for road-making. In accordance with the way in which they are made, bricks are sometimes called pressed bricks, or patent bricks, which latter term is applied indiscriminately by bricklayers to all machine-made bricks.

By the Act of Parliament now abolished, which imposed a tax of 5s. per thousand upon all bricks under a certain size, and double this amount on all such as exceeded 10 × 5 × 3 inches, which are rather in excess of the dimensions of an ordinary brick, it was also impossible to go over or dress the surfaces of any bricks, after they had once left the mould, without rendering them liable to an increased duty of 12s. per thousand. Under these circumstances, it is scarcely to be wondered at that for many years little was attempted in the way of improving this branch of manufacture. The Act of 1839, which made this duty a uniform sum for all bricks under 150 cubic inches in contents of 5s. 10d. per thousand, opened up an important and neglected industry, which has since then made great progress, and moulded and enriched bricks are now largely used for London buildings.

London, owing to the scarcity of stone in its vicinity, must always remain a brick city, and it is sad, knowing this to be so, to see how little has been done by London brickmakers to improve the ordinary stock brick, which is about as bad as it well could be.

Before concluding our remarks upon bricks, we may refer very briefly to the plan of using them as gauged or rubbed bricks. It was a very common practice in the "Queen Anne period" to put together a number of carefully-burned bricks, picked for evenness of colour, with the thinnest possible joints, and then to carve some ornament on this mass, dealing with it as if it were a block of stone. For all the best kinds of walling, moreover, the bricks were similarly selected for colour, and rubbed on a stone slab, to make the joints as thin as possible. The face of the finished wall was likewise rubbed over with a hard brick, till it was perfectly level and true. Such work constitutes the fine old red brickwork, which is frequently so much praised. A somewhat similar mode of preparing and using brick is now again coming into vogue; and opposed as it is to the nature and properties of the material considered with reference to its brick origin, we cannot but protest against this method of dealing with brickwork. To cut and carve bricks into all kinds of elaborate shapes when they have been hardened in the kiln, and to do at so much expense, when the clay has been burned, that which could have been so readily and cheaply done while it was in the plastic state, appears to us to be entirely wrong and false in principle. It does not come within our province to point out the best modes of using bricks, nor have we anything to do with the mortar or cement used for this purpose. On the vexed question of thick and thin joints, we may state that we are of opinion that a joint of about a quarter of an inch in thickness, as one which can readily be made with the ordinary consistency of mortar, and as furnishing a good and true bed for a fairly well-formed brick, should be insisted upon. The plan of making bricks with a large frog or kick on their upper and under surfaces, and of filling some kinds of bricks with small perforations, while it is by no means injurious, decreases their weight, and gives the mortar a good hold. We may conclude this part of our subject with the following simple directions: "Well wet your bricks before laying them, and let your mortar be as stiff as possible."

We shall divide our observations upon tile-making into two heads—namely, roofing and drain tiles, and flooring and wall tiles. Tiles specially intended for use as a roofing material have not, we think, the same antiquity as bricks. The ordinary roofing tile, known as a plain tile, which generally measures 10½ × 6½ × ⅝ inches, and weighs about 2½ pounds, seems to have been made on the model of a shingle. Shingles are thin strips of split wood used in the same way as tiles are used, and which in many parts of Germany and Switzerland, and even in some of our own rural districts up to the present day, are in almost universal use for every description of roofing.

The introduction of slate, owing to the increased facilities of railway communication with Wales and other slate-producing districts, seemed likely for a time to drive tiles completely out of the market. The weight of the tiles may be assumed to be about 15 cwt. per square of 100 superficial feet, while the same amount of roof space could be covered with 5 cwt. of the best slates. Then the slates are so much less porous, so much more readily fixed, and can be laid at such a much flatter angle than tiles, that for these and other similar reasons they have very largely replaced the old-fashioned tiling. It cannot, however, be forgotten that slating is a very dull and ugly looking substitute for tiling, and as tile manufacturers have recently been exerting themselves to give us a better made and lighter article than the old-fashioned pan or plain tile, we may hope to see tiles again largely used. Pan-tiles are larger than plain tiles, have an ogee section, and weigh about 5¼ lb. each. Both pan and plain tiles, and several other varieties we shall allude to further on, are generally made by brickmakers, and require appliances similar to those described for brick-making. Plain tiles can readily be made by machinery, but we are not aware that any machine exists for the production of pan-tiles.

The clay for tile-making requires to be of a tougher description than that used for bricks; and, as it will readily be understood, owing to the much greater thinness of tiles, requires a much more careful course of preparation. It is generally dug in the autumn, and allowed to remain all through the winter months in shallow pits, to fall and mellow, and is sometimes kept for a twelvemonth before it is used; it has to be carefully picked over to remove the stones, and it is generally tempered before use in small lumps by women or children, or it is passed twice, and sometimes three times, through a pug-mill. Having been further prepared by cutting it into numerous thin slices with a wire cutter called a sling—which process assists in removing the small stones, and is similar to the wedging or slapping of the terra-cotta clay—the clay is ready for the moulder. The lumps or pieces are roughly prepared by a boy in thin slices, about large enough to fill the mould, which is nothing more than a wood frame, a little over half an inch in thickness. Tiles are invariably made in sanded moulds, as slop-moulding cannot be employed. In Staffordshire coal-dust, and in Shropshire powdered burnt clay is used to facilitate the object leaving the mould. The clay having been filled into the mould, the surface is levelled, in some places with a wire cutter, in others with a round roller, like a cook's rolling-pin. The tile is then removed to dry, and when partially dry it is beaten with a thwacker, or placed upon a horse, to give it what is termed a set. The set is a slight curve, which is necessary in order to enable the tiles to bed evenly one upon the other when used for roofing. When thoroughly dry, the tiles are stacked in kilns, and burnt as bricks are burnt. It is a very common practice to burn bricks and tiles together, the bricks being at the bottom of the kiln and the tiles at the top. The tiles are built up on edge, as close as they will lie, in layers or "bolts," which cross one another at right angles. When they are burnt alone they do not require so much firing as bricks, in consequence of their small thickness.

It was formerly customary to punch a couple of small square holes through the tile, about 1½ inches in each way, at the top; through these holes wooden pegs were driven, by means of which the tile was hung upon the lath. This system has now been discontinued in most places, as not only was the tile much weakened thereby, and frequently broken by the insertion of the pegs; but it was also found that the dampness of the tile soon rotted the peg, which dropped off, and allowed the tile to slip off the roof. In lieu of the holes, therefore, a small stud or button of clay is cast on the under surface, just against the upper edge, which most effectually replaces the peg.

In making pan-tiles, the tiles are first moulded flat, and then given their proper curve on a specially-formed block. They are subsequently, when partially dry, trimmed up and finished on a thwacking-frame, and burnt in a special kiln. For a more minute description of what is, however, now an almost obsolete manufacture, our readers are referred to the article on "London Tileries," in "Dobson's Treatise." In Shropshire and Staffordshire a very small and thin tile is made of the well-known blue clay, which is burnt very hard, and which, owing to its imperviousness and lightness, makes an excellent roof material: such tiles are termed Broseley tiles.

Plain tiles are very frequently ornamented by having their lower ends made pointed or rounded off, and when used in alternate courses with common tiles, they have a very good effect. Such tiles are made in a similar way to the plain tiles, in a special mould. This kind of tiling is often used against the vertical wall of a house or cottage to keep out the driving rain, and in this form it is known as "weather tiling." The special tiles for covering the ridges and hips, and for forming gutters —known respectively as ridge, hip, and valley tiles—are hand-moulded on blocks shaped for the purpose; they are about the same price as pan-tiles. Ridge tiles are difficult to burn, and are generally placed one within the other on the top row of the kiln.

Drain tiles are properly small pipes: they were at one time made sectionally in the form of a horse-shoe, and were placed in the ground in the trenches prepared for them, with the open part downwards. In soft soils such draining was of very little use, as in a very short time the superincumbent weight pushed the tile down into the earth, and thus filled it up. These tiles, which were moulded flat and subsequently bent to the required shape, are, we believe, now no longer made. The ordinary circular drain tile, which may be from 1¼ to 3 inches in internal diameter, is made in a machine of simple construction, which can be readily worked by hand. A man and boy can turn out 4,000 or 5,000 in the course of a day. Before the introduction of these machines a strip of clay had to be rolled out or moulded of the required size, and then wrapped round a drum or mandril, the edges closed by hand, and after the tile had been shaped and finished the drum was withdrawn, and the tile stood upon end to dry.

There are numerous pipe-making machines now in use which are almost exactly similar in principle: the clay is first prepared in a pug-mill, and then pressed through an aperture in a steel die; the pipe is cut off from time to time, to any required length, by means of a wire cutter. Some machines make three or four tiles at each stroke of the piston. One of the most recent inventions is a machine for producing pipes by hydraulic pressure, which seems to work steadily and well. Pipes are stood on end, and built up one on the top of another, in the kiln. If it is required to give them a salt glaze, the fires are made up just as the kiln has got to its full heat, and a few handfuls of salt are thrown on each fire. The salt sublimes, and the soda therein combines with the silica in the clay to form a fusible double silicate of soda and alumina. Salt glazing is, we believe, almost invariably confined to down-draught kilns. A ring wall about half way up the kiln protects the goods from immediate contact with the flames, which pass up over this wall through the goods, and escape by means of numerous openings in the floor into the chimney. Pipes, tiles, and all thin clay goods, though they do not want quite so much care as more solid objects in the smoking process, require very careful and tender treatment under full firing.

In the production of simple ornamental roofing tiles some of our Continental neighbours are far ahead of us: there have been latterly, however, several new kinds of tiling brought under our notice. Among these are the corrugated tiles, made at Bridgewater, the Broomhall tiles, which are ribbed or fluted, and the so-called Italian tiles, which are a combination of rolls and flat tiles. The true Italian tiles are all semi-circular, and are laid alternately convex and concave. The mode of repairing leaky roofs in Italy may be all very well there, but would not do, we fear, with our lightly timbered English roofs. It consists in laying another layer of fresh tiles over the leaky ones, which are left as they are. We have seen old roofs in Milan with three or four thicknesses of tiling on them. For producing plain and moulded tiles by machinery the appliances are all of them similar to those previously described for brick and pipe making. We shall pass on in our next paper to the manufacture of flooring tiles.

AGRICULTURAL CHEMISTRY.—XI.

BY CHARLES A. CAMERON, PH.D., M.D.,

Professor of Hygiene in the Royal College of Surgeons, Ireland, etc.

CHAPTER XI.—CHEMISTRY OF FEEDING MATERIALS.

A KNOWLEDGE of the composition of feeding materials and of their comparative values is of great importance to the scientific farmer. No doubt the relative values of the ordinary foods consumed by the animals of the farm are tolerably well known to feeders who have had considerable experience in their business; but there are many alimentary substances occasionally employed in the feeding-house, of which the stock-feeder's knowledge is very limited. Indeed, it may truly be said that the great majority of farmers are by no means fully acquainted with those methods of fattening their stock, which out of a *minimum* quantity of raw materials (foods) produce a *maximum* amount of beef, mutton, and pork.

The space at our disposal does not admit of our going minutely into the physiology of the animals of the farm, or the chemistry of food: we can but state the composition of the principal nutritive substances used in the feeding-house, and briefly indicate their adaptability to the wants of the different varieties of stock.

The proximate ingredients of vegetables used as food are arranged under three heads:—

(1) Nitrogenous, albuminous, or flesh-forming bodies, containing the chemical elements, carbon, hydrogen, oxygen, nitrogen, and small proportions of sulphur and phosphorus; (2) non-nitrogenous or fat-forming bodies, containing carbon and the elements of water, hydrogen and oxygen; (3) mineral or incombustible matters, or *ash*. Caseine, albumen, and fibrine are examples of nitrogenous bodies, and they resemble each other and all other albuminoids very closely in composition. Sugars, starch, pectose bodies, gum, and woody fibre (cellulose) are termed carbo-hydrates, and together with oleaginous or fatty bodies, they constitute the non-nitrogenous group of food materials. In nutritive power it is considered that 2½ parts of digestible carbo-hydrates equal 1 part of fatty matter. We do not know of any difference between the nutritive power of the various albuminous substances. Cellulose is, there is good reason to believe, digestible on the stomach of a ruminant, provided it be derived from young and succulent plants; old woody fibre can have but little, if any, nutritive properties. Pectose bodies constitute a rather large proportion of the nutritive matters found in roots and foliage. Pectose proper is the substance, the presence of which in the juices of various fruits, causes them to gelatinise; hence pectose is also termed vegetable jelly. As to the nutritive property of gums some doubt has been expressed, but we believe that they really do possess alimentative properties. We shall now describe the composition of the commonly employed feeding-stuffs.

Green Food.—The grasses, natural and artificial, constitute the most abundant food of live stock. Amongst the most nutritious grasses may be enumerated Italian rye-grass, annual meadow-grass, meadow barley, crested dog's-tail-grass, Timothy, or meadow cat's-tail-grass, cock's-foot-grass, and sweet-vernal grass. Amongst grasses of medium quality may be mentioned smooth and rough-stalked meadow-grass, meadow foxtail-grass, and waterwhorl-grass. The rough-stalked meadow-grass is perhaps the least nutritious of those mentioned; but it is superior to meadow soft-grass, false brome-grass, upright brome-grass, and creeping soft-grass, which, together with other kinds grown, do not deserve to be cultivated.

In grasses we find from 70 to 78 per cent. of water, 2 to 4 per cent. of albuminates, about 1 per cent. of fatty bodies, 10 to 20 per cent. of fat-formers (starch, etc.), and from 5 to 15 per cent. of woody fibre.

The artificial grasses (which on the whole are more nutritive than the natural grasses) include the different varieties of clover, vetches, lucerne, and a few other plants, most of which are rarely cultivated. Clovers are very valuable plants, rich in both flesh and fat forming materials, and very succulent and tender. Of the different varieties *alsike* appears to be the best, as it contains a very high proportion of nutritive matter, besides usually giving an abundant yield. The composition of the vetch, sainfoin, and lucerne closely resembles that of the clovers. Lentils, birdsfoot, trefoil, melilot, and lupines are leguminous plants, and are all valuable forage crops.

According to Dr. Anderson, red clover contains from 79 98 to 85·3 per cent. of water, 14·7 to 21·02 per cent. of dry substances, 2·31 to 2·87 per cent. of albuminates, and from 1·3 to 1·58 per cent. of ash; cow-grass contains from 77·39 to 81·76 per cent. of water, 18·24 to 22·61 per cent. of dry substances, 2·25 to 3·19 per cent. of albuminates, and 1·92 to 2·73 per cent. of ash; crimson clover contains 82·56 per cent. of water, 17·44 per cent. of dry substances, 3·25 per cent. of albuminates, and 1·88 per cent. of ash; yellow clover contains from 77·38 to 78·60 per cent. of water, 21·4 to 22·62 per cent. of dry substances, 2·94 to 3·5 per cent. of albuminates, and from 1·75 to 2·02 per cent. of ash. Green rye is occasionally employed as a forage crop; it is about equal to good clover.

Rape is one of the most valuable of the crops used for stock-feeding in these countries; not because its feeding value is high, but simply owing to its being generally obtained as a *stolen* crop, that is, a crop obtained from a field which has produced or is to produce another crop in the same year. 100 parts of rape contain, according to Voelcker, 87·05 per cent. of water, 3·133 per cent. of albuminates, 0·649 per cent. of fats, 4 per cent. of starch and gum, 3·56 per cent. of fibre, and 1·608 per cent. of ash.

The mustard plant is sometimes grown for sheep. It is richer in flesh-formers than rape, and in other respects it is about equally nutritious with the latter. The prickly comfrey, chicory, and yarrow (the latter is usually considered to be little better than weeds), are all somewhat inferior to clover and rape. Melons and marrows are occasionally used as food for cattle, but their nutritive power is very low. The cabbage possesses very good feeding properties, and is worthy of greater attention from the stock-feeder. Dr. Anderson has investigated the composition of the drumhead cabbage. He found that the "heart" and inner leaves were less nutritious than the outer leaves, and that the young plants were the richest in nourishment. These results show the desirability of cultivating the open-leaved varieties of this plant. Cabbages are much relished by cattle and sheep, and the butter of cows fed upon them is free from the disagreeable flavour which is often noticed in butter from the milk of cows fed on turnips. It is to be regretted that cabbages do not admit of being stored, as otherwise they might be much more extensively cultivated than is now the case.

The following is Voelcker's analysis of the cattle cabbage (heart and inner leaves in a fresh state). 100 parts contain :—

Water	89·42
Oil	0·08
Soluble albuminates	1·19
Insoluble albuminates	0·31
Sugar, digestible fibre, etc.	7·01
Woody fibre	1·14
Ash	0·85
	100·00

Furze (gorse or whins) is a plant that might with advantage be grown upon poor soils, especially in the uplands. It is very hardy, and is able to withstand prolonged drought. It is relished (when bruised) by every kind of stock, and even horses thrive upon it. I find furze cut on the 15th of August, the shoots mostly consisting of the year's growth, to have the following composition. 100 parts contain :—

Water	72·00
Albuminates	3·21
Oil	1·18
Fat-formers (starch, etc.)	8·20
Woody fibre	13·33
Ash	2 08
	100·00

Dry Fodder.—Straw consists of the dried stems of cereal and leguminous plants. Most kinds are valuable foods, and indeed it appears to me that farmers do not estimate at the full value the feeding properties of good oat and barley straw.

The quality of straw is very much influenced by the manner in which it is harvested. If it is cut early, speedily removed from the field, kept from the wet and properly stacked, it will often (in the case of oat-straw) be found to closely approach hay in nutritive value. When the upper part of the stems of corn plants changes from a green to a yellowish hue, nothing is to be gained by delaying the reaping of the crop. The change of colour indicates that the vegetative functions of the plants have come to an end, and that henceforth, instead of increasing, they will diminish in weight, and that they will certainly deteriorate in quality the longer they remain uncut. Over-ripene straw is often of very inferior quality, whilst the stem, cut whilst a large portion of it is still green, is one of the best staple foods of both horned stock and horses. Perhaps the best way to give a clear idea of the value of straw properly harvested, is to compare it with linseed-cake in the following manner :—One ton of good oat-straw (at say 30s. per ton) contains 22·4 lb. of oil, 89·6 lb. of flesh-formers, 224 lb. of sugar, starch, gum, and 672 lb. of digestible woody fibre = 1,008 lb. of nutritive matters; or if we calculate the fat as being equal to 2¼ times its weight of starch, then the total nutriment would be—fat-formers, 952 lb.; flesh-formers, 89·6 lb.; total, 1,041·6 lb. On the other hand, one ton of good linseed-cake (at say £11 10s. per ton) contains of flesh-formers, 582·4 lb.; fat-formers (oil, 268·8 lb., gum, sugar, etc., 761·6 lb.), 1,508; fibre, 74·4 = total nutriment (the fats being multiplied by 2·5), 2,090·4 lb. These comparisons show us that we get 1,000 lb. weight of nutriment in the form of straw for 30s., whilst for the same weight of nutriment in the form of oil-cake we pay £5 15s. No doubt, in the matter of quality, and in the presence of a large proportion of ready-formed fats, the oil-cake is superior to the straw; nevertheless, these advantages appear to be purchasable at a very high cost.

ANALYSES OF OAT-STRAW.

	From Co. Wicklow.	Obtained in the Dublin Market.		
	No. 1.	No. 2.	No. 3.	No. 4.
Water	14·00	14·00	14·00	14·00
Flesh-forming principles—				
a. Soluble in water . . .	4·08	2·02	2·04	1·46
b. Insoluble in water .	3·09	3·16	3·00	2·23
Oil	1·84	1·40	1·26	1·00
Sugar, gum, and other fat-forming matters . . .	13·79	12·67	10·18	11·16
Woody fibre	59·96	61·79	65·45	65·29
Mineral matter . . .	4·24	4·96	4·07	4·86
	100·00	100·00	100·00	100·00

No. 1 was barely ripe; the others had been allowed to remain far too long uncut.

ANALYSES OF WHEAT-STRAW.

	Green changing to yellow. County Kildare.	Ripe. County Dublin.	Over Ripe. County Dublin.	Obtained in the Dublin Markets.		
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Water . . .	13·00	13·15	12·14	10·83	11·22	12·12
Flesh-forming principles—						
a. Soluble in water	1·25	0·98	0·44	0·06	0·42	0·30
b. Insoluble in water . .	1·26	1·40	1·41	1·90	1·00	1·76
Oil	1·22	1·13	1·14	0·90	1·17	1·08
Sugar, gum, and other fat-forming matters	4·18	3·98	3·88	4·08	3·89	4·30
Woody fibre . .	75·84	76·17	77·76	78·67	79·18	77·15
Mineral matter (ash)	3·25	3·19	3·23	3·51	3·12	3·29
	100·00	100·00	100·00	100·00	100·00	100·00

With respect to their nutritive value straws stand in the following order, the most nutritious being first :—Pea-haulm, oat-straw, bean-straw with pods, barley-straw, wheat-straw, bean-stalks without the pods.

Hay consists of a different admixture of dried natural and artificial grasses, and its composition is consequently very variable. According to Voelcker, the following represents the average composition of meadow-hay, as deduced from twenty-five analyses of it :—

Water	14·61
Flesh-formers	8·44
Fat-formers	43·63
Fibre	27·16
Ash	6·16
	100·00

According to Way, the herbage of water-grass meadows is richer in nutritive matter than that of dry meadows.

According to Dr. Anderson, the composition of clover hay, of the second cutting, is as follows :—

Water	16·84
Flesh-formers	13·52
Fat-formers and fibre	64·43
Ash	5·21
	100·00

There does not appear to be any difference between the composition of the first and second cuttings of hay, if both be saved under the same conditions. Hay should be cut before the plants ripen fully, and even before they flower: enormous losses of its nutritive principle take place from the frequent practice of allowing it to remain in the field for days and weeks exposed to rain and sunshine. In Ireland a competent authority estimates the loss from this source at a fifth part of the whole crop.

Roots and Tubers.—The majority of roots used as cattle food possess but very little nutritive power, but the great quantity in which they are produced renders them a most important and indeed an almost indispensable element in the production of beef and mutton. Tubers are far more nutritious than roots, but the potato is the only tuber generally used in stock-feeding.

ANALYSES OF ROOTS AND TUBERS.

(By Voelcker, Anderson, and the Author.)

	Swedish Turnip.	White Globe Turnip.	Aberdeen Yellow Turnip.	Norfolk Bell Turnip.	White Beet.	Parsnip.
Water .	89·460	90·439	90·578	92·280	83·0	82·00
Flesh-formers	1·443	1·143	1·802	1·737	2·5	1·30
Fat-formers .	5·932	5·457	4·622	2·962	11·5*	7·75
Fibre . . .	2·542	2·342	2·349	2·000	2·0	8·00
Ash . . .	0 623	0·628	0·649	1·021	1·0	0·95
	100·000	100·000	100·000	100·00	100·0	100·00

	Carrot.	Kohl Rabi.	Potatoes.		
			Regents.	Dalmahoys.	Kerry Blues.
Water	88·50	87·62	76·32	75·91	76·60
Flesh-formers . . .	0·60	2·24	2·37	2·25	2·06
Fat-formers . . .	10·15	7·78	14·96	15·53	14·88
Fibre		1·34	5·53	5·21	5·41
Ash	0·72	1·22	0·88	0·81	0·94
	100·00	100·20	100·06	99·71	99·89

Seeds.—The most concentrated and valuable food is that furnished by seeds. Not only do they contain very large amounts of "dry substances," but their ingredients are in the highest degree elaborated or organised, and therefore they can be most easily assimilated by animals.

AVERAGE ANALYSES OF GRAIN.

	Barley.	Bere.	Oats.	Outmeal.	Indian Corn.	Rice.	Rye (Irish).	Buckwheat.
Water . . .	16·0	14·25	14·0	13·00	14·5	14·0	16·0	14·19
Flesh-formers .	10·5	10·10	11·5	16·00	10·0	5·3	9·0	8·58
Fat-formers . .	67·0	64·60	64·5	68·00	69·0	77·5	66·0	51·91
Woody fibre . .	3·5	9·03	7·0	1·75	5·0	2·5	8·0	23·12
Mineral matter .	3·0	2·02	3·0	1·25	1·5	0·7	1·0	2·20
	100·0	100·00	100·0	100·00	100·0	100·0	100·0	100·00

Oat-grass is the most nutritious of the seed consumed by stock. The white kind is considered the best. The husk of this grain is very inferior to wheat-bran, and oat-toppings are generally not worth the price at which they are sold. Indian corn is a good food, and from its large amount of ready-formed fatty matter it is well adapted for dairy cows and bullocks in stalls. It is excellent food for pigs. Barley is inferior to oats, but still barley-meal is an excellent food, and *barley dust* is often a cheap feeding-stuff. Barley husks should not be given in an uncooked state, as they are apt to irritate the digestive organs. Wheat is not often given to cattle; it possesses a very high degree of nutritive power, and its bran is an excellent feeding-stuff. Malted barley is a good food for milch-cows, but it is doubtful if any advantage be derived from converting barley into malt. Malt combs, or dust, under £4 per ton may be regarded as cheap. They are very rich in albuminates.

Leguminous seeds are rich in flesh-forming elements, and they are consequently adapted for young stock. They are *binding*, and therefore must not be largely used, unless they are combined with some laxative material. These seeds contain from 23 to 26 per cent. of flesh-formers (chiefly *legumine* or vegetable caseine), from 47 to 50 per cent. of fat-formers, and about 10 per cent. of woody fibre. The different kinds of leguminous seed hardly differ in composition.

Oil Seeds (linseed, rape-seed, hemp-seed, and cotton-seed) are not much used as cattle feeds on account of their high price. They contain from 31 to 37 per cent. of oil, 22 to 32 per cent. of albuminates, and from 24 to 35 per cent. of non-nitrogenous substances. *Oil Cakes* consist of the residue of oil seeds from which a certain amount of oil has been expressed. The following is their average composition:—

AVERAGE COMPOSITION OF OIL-CAKES.

	Linseed Cake (English)	Rape Cake.	Decorticated Cottonseed Cake.	Poppy Cake.
Water	12	11	9	
Flesh-forming principles .	28	30	38	
Oil	10	11	13	
Gum, mucilage, etc. . .	34	30	23	
Woody fibre	10	10	9	
Mineral matter (ash) . .	6	8	8	
	100	100	100	100

Linseed-cake is a very valuable feeding-stuff, greatly in use, and more especially in completing the fattening of oxen. The cake should have a reddish-brown colour, a uniform appearance, and a rather agreeable flavour and odour. The adulterated cake is generally greyish, and often has an unpleasant odour. It is sometimes adulterated with earthy matter, in which case its great weight will betray the nature of the impurity. If about ½ oz. be powdered and mixed with a small wine-glassful of water, the paste should be moderately stiff, light-coloured, and well-flavoured. If, on the contrary, the paste be thin, it is probably adulterated, in which case bran or grass-seeds are probably present. By means of a small magnifying glass grass-seeds and other impurities may readily be detected if present in the paste.

Rape-cake is not so well flavoured as linseed-cake, and although it contains rather more oil and flesh-formers than the latter, its commercial value is more than one-third less. There exists considerable difference of opinion relative to the nutritive properties of rape-cake, some feeders believing it to be fully equal to linseed-cake, whilst others think it dear at half the price of the latter. Rape-cake often contains a large proportion of mustard, and it naturally includes an acrid substance which renders its flavour unpleasant. These are often the cause of the failure of rape-cake as a food for stock. When, however, the cake is free from mustard and of good quality, there is no doubt as to its being a more economical feeding-stuff than linseed-cake. It is much improved by being thoroughly steamed, and the addition of a little molasses renders it very agreeable to cattle.

Palm-nut meal is a very fattening food, containing from 14 to 17 per cent. of fats, from 17 to 20 per cent. of albuminates, and about 52 per cent. of non-nitrogenous matters. Taking into account its high per-centages of nutritive materials, it is a cheap food at its present price. It is largely given to pigs, but cattle at first do not usually relish it on account of its strong flavour; however, they soon acquire a fondness for it.

Condimental Foods consist, in general, of mixtures of locust beans (an article which contains nearly half its weight of sugar), Indian corn, or other grain, and certain aromatic ingredients. The following formula will be found as good as any:—Linseed-meal or cake, 7 cwt.; locust beans (ground), 8 cwt.; Indian corn, 4 cwt. 1 qr.; powdered turmeric, 1 qr. 14 lb.; ginger, 3 lb.; fenugreek seeds, 2 lb.; gentian, 10 lb.; cream of tartar, 2 lb.; sulphur, 20 lb.; coriander seed, 5 lb.; common salt, 10 lb. = 1 ton. This will be found a better and cheaper preparation for horses out of condition, and for bullocks in the last stage of fattening, than any of the commercial "condimental foods."

Including 10 of sugar.

TECHNICAL DRAWING.—LI.

GOTHIC STONEWORK.

Fig. 448 is an example of an arch taken from the triforium arcade in the north transept of the cathedral at Chester, probably one of the most ancient of the Norman portions of the edifice. It would be described architecturally as a "semicircular arch of a *single order*, with square edges"—the term "order" being in this case used to designate the course of stones of which an arch is formed.

Fig. 449 is a sketch of the spring of the tower arches of St. John's, Chester, showing the method of construction. There are three courses of voussoirs, forming three receding faces. These arches would be described as of "three orders with square edges;" or simply as "triple recessed arches with square edges."

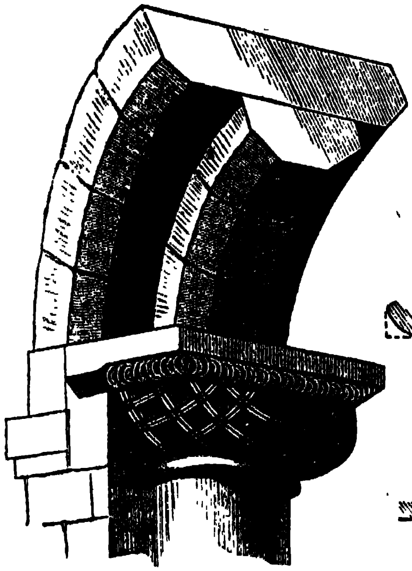


Fig. 450.

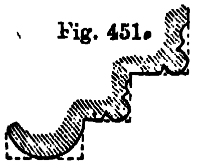


Fig. 451.

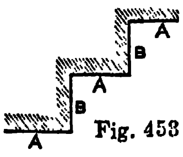


Fig. 453

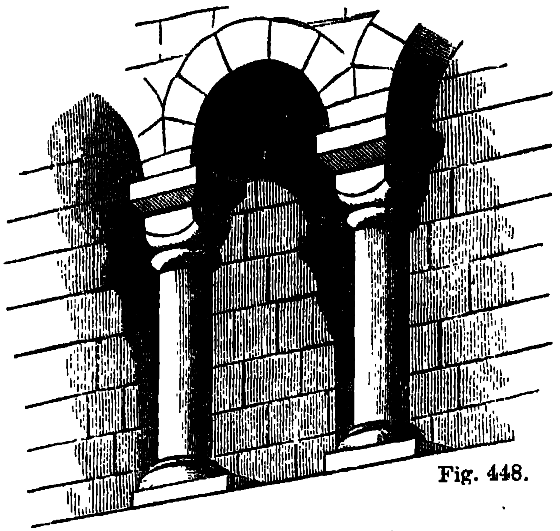


Fig. 448.

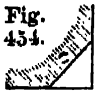


Fig. 454.

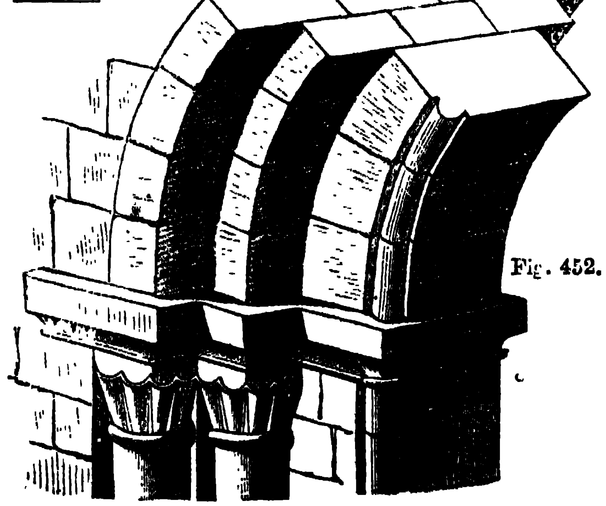


Fig. 452.

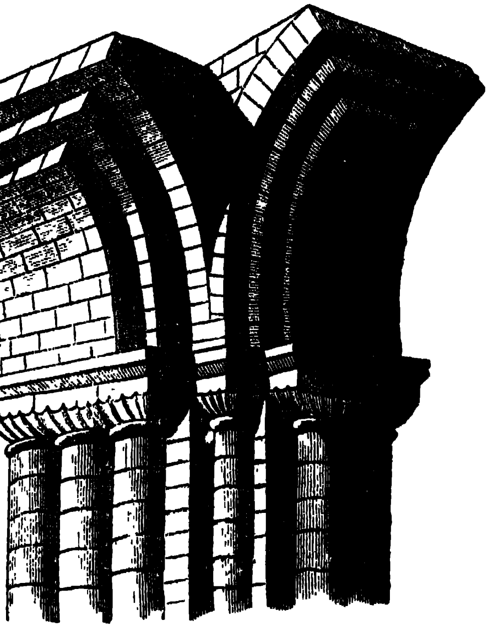


Fig. 449.

OF THE ORIGIN OF MOULDINGS.

The first step towards the introduction of mouldings appears to have arisen from the desire to do away with the massive and rude appearance of the square edges, and to lead the eye gradually from the front plane of the wall to the central plane of the aperture, instead of by the sudden step-like rims which a series of "square-edged orders" presented.

The simplest way of doing this is by cutting away or removing the square edge. An arch of two orders with chamfered edges is shown in Fig. 450. It is taken from the ruins of the priory at the east end of St. John's, Chester. It is, however, remarkable, observes the Rev. T. N. Hutchinson (whose excellent lectures and writings on this special section of the subject are often referred to), "that, simple as this method is, it does not appear to have been the first resorted to. The arch in question is of late date for Norman work, if indeed it be not of Transition character. It is also remarkable that this way of removing the square edges of two or three orders continued in use during all the subsequent styles of Gothic architecture."

The earliest attempts at removing the plainness of the chamfered edges consisted in simply rounding them off, thus giving the appearance of a heavy semi-cylindrical ring. The first of the three orders, or "sub-arch," as it would be correctly called, is frequently found rounded off in this way. There is a good example in the south aisle of the choir of St. John's, Chester, a section of which is illustrated in Fig. 451. A more effectual way, however, was generally followed. Instead of simply rounding off the edge, a portion of the stone on either side was cut away, thus leaving the cylindrical roll clearly defined, and affording a more decided effect of light and shade. Fig. 452 is an example of this method; it occurs in an arch in the west cloister of Chester Cathedral, formerly leading to the abbot's apartments. In this figure it will be observed that two of the orders are left with the square edges, the first or sub-arch only having the moulding referred to. The mediæval name of this moulding is the "bowtell," but it is more frequently spoken of as the "Norman edge-roll."

The roll moulding with side hollows appears to have been the only attempt at this kind of decoration in use among the early Norman architects. They confined their ingenuity to ornamenting the flat surfaces of their arches with rude sculpture, and arches of two or more orders are constantly found, in which the entire surfaces are covered with bands of ornaments: in some, as the west door of Rochester, the entire semi-circular space (or tympanum) between the arch and the springing is filled in with sculpture.

One law, however, pervades all the Norman mouldings. They are invariably arranged on rectangular faces, so that two lines at right angles would exactly touch the front face and under portion of the moulding.

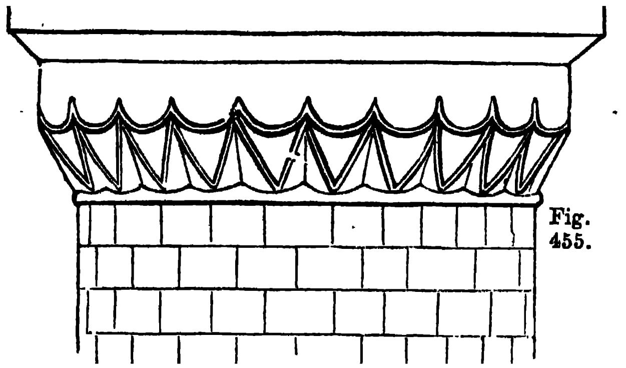


Fig. 455.

These planes have been distinguished by Mr. Paley as the wall plane—that is, any plane, A A (Fig. 453), parallel to the main wall; the soffit plane, B, or any plane at right angles to the face of the wall; and the chamfer plane, C, or such plane (Fig. 454) as is generally, but by no means invariably, placed at an angle of 45° with the two planes before mentioned.

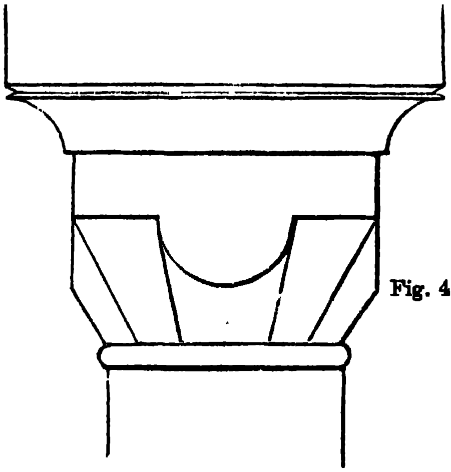


Fig. 456.

Norman Piers.—The piers usually employed in the Norman period are of four kinds:—

1. Round, massive, columnar piers, which have sometimes a round and sometimes a square capital. They are sometimes plain, and sometimes ornamented with channels in various forms; some plain zigzag, some like network, and some spiral. They are met with of various heights, from two to six, or even seven diameters.

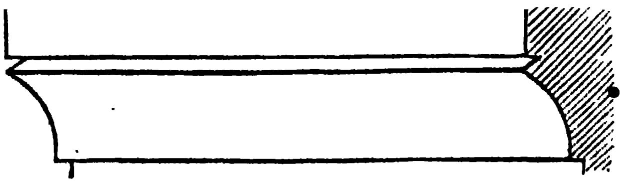


Fig. 457.

2. Multangular. Generally octagonal, as if the pier had been originally square, and the angles chamfered off as in the case of the mouldings. These are often met in connection with arches more or less pointed.

3. Common piers with shafts. These have sometimes plain capitals, but are sometimes much ornamented with rude foliage, and occasionally animals. The shafts are mostly set in square recesses in the angles of square piers.

4. A plain pier, with perfectly plain semi-circular arches in two or three divisions.

Norman capitals are of great variety of character. Some are rude and unskilful imitations of classical examples, but the most common is the "cushion capital" (shown in Fig. 448). This is of cubical form, being rounded at the lower end to meet the shaft, the profile of the curve presenting somewhat of the appearance of the ovolo moulding. Sometimes the capital consists of many such figures of small dimensions, placed side by side (Fig. 455), the flat surface presenting a scalloped appearance, and beneath each of the scallops is a kind of inverted cone which meets the neck mould of the shaft. Some have interlaced bands and some foliage carved in slight relief, whilst others are sculptured with grotesque representations of men and animals. Fig. 455 from St. John's, Chester, and Fig. 456 from Waltham Abbey Church, Herts, are examples of the capitals alluded to.

Fig. 457 is a feature of common occurrence in Norman architecture. This is the moulding of the square abacus over the flowered or cut part of the capital. It consists of a broad fillet or hollow, separated by a sunk channel, and it is sometimes continued as a tablet along the wall.

SANITARY ENGINEERING.—XIII.

VENTILATION OF PUBLIC BUILDINGS.

In our last paper we treated of what may be called domestic ventilation, and noticed various appliances for the admission of fresh air and the exit of foul air in apartments used for ordinary residential purposes. In the present article we propose to deal with public buildings generally, and to give a few data as to the best means of obtaining efficient ventilation under all circumstances.

When a room is used for residential purposes the conditions of the atmosphere vary comparatively little, the difference between winter and summer or fire and no fire probably representing the extremes to be provided for. But in public buildings the case is very different—the audience in theatres, the congregation in churches and chapels, occupying the building perhaps for an hour or two only, and changing entirely the atmospheric position of the contents.

Perhaps there is no single building to the ventilation of which more attention has been paid than to the House of Commons. Here we have a large audience—as the members may perhaps fairly be called—occupying the building not only for an hour or two, but often for many hours in succession, sometimes almost through the night; and the warming and ventilating of what we may venture to call one of the most important of all rooms or chambers has occupied the attention of many of the first scientific men, both of this generation and some preceding it. Sir Humphry Davy made this matter the subject for a special report; the Marquis de Chabannes projected a special scheme for the purpose in the early part of the present century; while more recently it became a subject upon which Dr. Reid was especially engaged, and on which he has published an octavo volume to which we are indebted for some of our details.

The heating and ventilation of the House, as it will be readily understood, are dependent upon each other, and arrangements of the most elaborate and complicated kind were made by which they might be under the most complete control, the admission of warm air regulated by a valve under constant supervision and instant command being a leading feature in the scheme. The only departure from the general principles laid down in our previous paper was that the vitiated air, rising to the air-chamber above a glass ceiling purposely constructed, was carried first down to the ground level by a descending shaft, and then discharged through a lofty flue specially erected for the purpose at a considerable height in the air. Certain constructional conditions led to the adoption of the plan; but we cannot do better than here quote Dr. Reid's opinion (page 282 of the edition of 1844):—"That in buildings constructed originally with a view to ventilation, it is desirable to have no *descent* of warm air.'' Anything approaching a detailed account of the various portions of the system is entirely beyond the limits of our present space: we may, however, quote a few of the results arrived at by actual experiments, as valuable data for parallel undertakings. A chamber was provided for moistening, drying, and cooling the air; besides the heating apparatus, arrangements were also made, by introducing the fresh air through a gauze veil, to prevent the entry of any palpable portions of soot; and every care was taken to prevent the access of offensive air from drains, from the river, or of the various sources of offence to which the peculiar situation of the House of Commons renders it so exceptionally liable. As a practical point we may note (page 294), that the House is heated to 62° before it is opened, and maintained in general at a temperature of 63° and 70°, according to the velocity with which the air passes through the House. Knowing the constant attention paid to the subject, the temperature of the House became a constant subject of discussion. We may imagine the difference of feeling between a weakly member, who had been sitting long in the House and had not dined, and a healthy man just come in after dining at his club. In practice the following system was adopted: all complaints on ventilation questions came gradually to be addressed to the serjeant-at-arms, who regulated the temperature by the wishes of the majority.

A similar series of difficulties has also been encountered in the ventilation of the House of Lords, and dealt with upon the same general principles.

We now propose to make a few remarks upon some of the errors most common in the ventilation of churches, chapels, and similar buildings which create the draughts that are so often a subject of complaint. A common practice is to depend upon opening a window for the admission of fresh air when the temperature rises above a certain point. What is the consequence? A column of air is admitted much colder than the body of the atmosphere of the building itself; it sinks more or less rapidly, as a natural consequence, and every person sitting within its range feels the draught. If the body of air were admitted by means of distributed openings below or at the floor level, the temperature could be regulated by a thermometer to the greatest nicety, with the certainty that the heat of the upper strata would very soon make its escape, carrying with it the deleterious remanets of respiration and combustion. Lateral ventilation, therefore, or the opening of opposite windows with a view of creating what is popularly called a thorough draught, should never be attempted in public buildings. The temperature will, of course, vary at different levels; the portion that may be taken as a guide to the whole being that occupied by the audience. In churches where there are no galleries the matter is very simple, as the section of height, if we may so describe it, which contains the pews and the pulpit, has only to be considered; and if this is kept at a comfortable temperature, it is evident that the heat of the upper portion or the cold below the floor are equally matters of indifference; but of this we may be sure, that any opening of windows, which from the necessary architectural conditions to be preserved are far above either level, will be immediately evidenced by a direct down draught. Another error, often committed, is the *unlimited* supply of air from below. As an instance, we may mention a well-known church at the West-end, which was erected within the last few years, and has been notorious for what may be called the impossibility of warming it. The warming process in this case was carried out by warm water on the principle explained in our paper, No. IX. The area of the pipes provided was barely sufficient to sustain the requisite temperature for comfort in ordinary weather, and the curious error was committed of admitting an unlimited supply of cold air into the basement of the building; the natural result followed. As soon as the air became warm by the hot-water pipes, it rose to the roof and escaped, and the openings below were so ample that it was difficult to raise the atmosphere of the body of the church many degrees above that of the external air. When there is a gallery in a church, or more than one, as is sometimes the case, the conditions then to be dealt with approach those of a theatre, where the audience occupy the whole space, as we may say, from floor to ceiling, and where, from the constant opening of doors at different levels, the balance of the air is likely to be more constantly disturbed. Who has not noticed the rush of cold air into the body of a crowded house when the doors are opened between the acts? There is very little difficulty in the warming of theatres, but much in their ventilation. It only remains to lay down the general principle that the air heated, whether by natural or artificial causes, naturally ascends, carrying with it its carbonic acid gas; and that by a proper attention to egress and ingress the temperature of a theatre can be regulated with the same nicety as that of an ordinary room. The grand motive power in all cases is the rise of the heated air; and in some cases, in dealing with theatre ventilation, it may be desirable to have exits at various levels for the benefit of different ranges of boxes, which may also be provided with fresh air in a similar way. We may notice, as a case of the recent adoption of this principle, the private boxes of Evans's, Covent Garden, each of which has its own separate open flower ventilator in the centre, communicating directly, by means of a zinc pipe, with the external air.

We have often thought that if efficient and well-considered architectural arrangements were made in the first instance, and a very moderate outlay incurred in the current expense of a small intelligent staff, whose duty it should be to regulate the temperature of the various parts of the house as circumstances might dictate, much, if not all, of the inconvenience often complained of as to the inefficient ventilation and unwholesome atmosphere of our theatres and similar buildings might be altogether obviated.

Another class of public buildings is far more readily dealt with: we allude to reading rooms and museums. In these cases artificial warmth is always required at some periods of the year in this climate, either for the comfort of the readers, or for the preservation of specimens either of natural history or similar objects from the effects of our damp atmosphere. The warming may be effected by any of the methods described in our previous papers—a most desirable result to be obtained being that the fresh air should be warmed *before* it is admitted from below, that it should gradually rise as much as possible without draught to the ceiling, and thence to the external air. It is by no means an uncommon mistake to be content with providing an exit from the ceiling into the open space within the roof: this is by no means always sufficient, as the system generally adopted now-a-days of covering roofs with felt under the slates renders them in point of fact mere hot-air chambers, from which an accidental down-draught may send down the vitiated air upon the inmates below. A shaft, and, if possible, of some considerable elevation, should always be provided at the highest point of the building for the general escape of foul air; and if the smoke flues of the building are built in conjunction but not in communication with it, their warmth will materially assist the up-draught. This point we shall not enter on further at present, as in our next paper on ventilation of hospitals we shall go into it upon a more extensive scale.

In concluding our present notice we have only space for a passing allusion to the ventilation of ships' decks, which, though not strictly within our limits, is most important and interesting to a large section of the community, as it has been well known for many years that the sleeping accommodation of a large proportion of our seamen is most deficient in this respect. The hammocks in many cases are swung between decks as near to the upper deck as may be, often above the portholes. The same results accordingly occur as we alluded to in our last paper on ill-ventilated rooms: the upper section of the air becomes thoroughly vitiated, and in case of change of watch in bad weather, men have to pass at once from this heated atmosphere, probably in a state of profuse perspiration, into the external air, which may be at a temperature below the freezing point. A careful attention to the general principles laid down above, into the mechanical details, however, of which we have not room to go, will enable all these difficulties to be obviated—if provided for in the original construction of the vessel—at comparatively moderate expense, especially in the case of steam-ships, where the heat generated by the boilers, etc., may be made available as the motive power of a most efficient system of ventilation, extending through every part of the ship.

We shall in our next paper deal with the method of ventilation of hospitals; and as we consider the subject of special importance just now, we shall endeavour to give full details of some two or three of our largest London hospitals.

NOTABLE INVENTIONS AND INVENTORS.

XXII.—THE MARQUIS OF WORCESTER AND HIS "CENTURY OF INVENTIONS."

BY JOHN TIMBS.

Edward Somerset, sixth Earl and second Marquis of Worcester, the celebrated speculative mechanical inventor, stands almost isolated in the British peerage, but he has the superior honour of being regarded as one of the chief inventors of the steam-engine. Living in the time of the Civil War, he took part with King Charles I., who visited the Marquis several times at his castle of Raglan, the picturesque ruins of which admiring topographers to this day regard as "a romance in stone and lime." The King invested Worcester with the command of a large body of troops; but his bravery and devotedness to the royal cause failing in Ireland, he embarked for France, where he attached himself to the suite of Charles II., who then resided at the French Court, and in the following year dispatched the Marquis to London to procure private intelligence and supplies of money. He was, however, speedily discovered, and committed a close prisoner to the Tower of London. He was much attached to scientific pursuits, which accident is said to have directed in a proper course. It is related that, one day preparing some food in his apartment, the closely-fitted cover of the vessel was, by the expansion of the steam, suddenly forced off, and driven up the chimney. It then occurred to him that the same power might be applied to useful purposes; and the germ of the lesson was treasured in the first manuscript of his "Century of Inventions," which he wrote in France, but lost. He, however, re-wrote the work after his committal to the Tower, as inferred from a manuscript now in possession of the Beaufort family, which opens thus:—

"A Century of the Names and Scantlings of such Inventions

as at present I can call to mind to have tried and perfected, which (my former notes being lost) I have, at the instance of a powerful friend, endeavoured now, in the year 1655, to set these down in such a way as may sufficiently instruct me to put any of them in practice.

"*Artis et Naturæ proles.*"

Lord Worcester was set at liberty at the Restoration, and produced a working machine. In 1663 appeared the first edition of the "Century of Inventions;" and in the same year Parliament granted to Worcester and his successors the whole of the profits that might arise from the use of an engine described in the last article in the "Century." He likewise published his "Exact and True Definition of the Most Stupendous Water-commanding Engine," in a small quarto volume, consisting of only twenty-two pages, which is now extremely rare. His lordship survived the publication of his work but two years, as he died in retirement near London in 1667, and his remains were interred in the cemetery of the Beaufort family, in Raglan Church.

The "Water-commanding Engine" is described in the "Century" (No. 68) as "An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosopher calleth it, *infra sphæram activitatis*, which is but at such a distance. But this way hath no bounder, if the vessel be strong enough; for I have taken a piece of the whole cannon, whereof the end was burst, and filled it three-quarters full, stopping and screwing up the broken end, as also the touch-hole; and making a constant fire under it, within twenty-four hours it burst and made a great crack; so that having found a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, have seen the water run like a constant fountain stream, forty feet high. One vessel of water, rarefied by fire, driveth up forty of cold water; and a man that tends the work has but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same person may likewise, abundantly perform in the interim, between the necessity of turning the said cocks."

We now pass on to No. 98 of the "Century:" "An engine, so contrived, that working the *primum mobile* forward or backward, upward or downward, circularly or cornerwise, to and fro, straight, upright or downright, yet the pretended operation continueth and advanceth, none of the motions above-mentioned hindering, much less stopping, the other; but unanimously and with harmony agreeing, they all augment and contribute strength unto the intended work and operation; and therefore I call this a semi-*omnipotent engine*, and do intend that *a model thereof be buried with me.*" [Whether this intention was carried out is uncertain.]

"No. 99: How to make one pound weight to raise an hundred so high as one pound falleth, and yet the hundred pounds descending doth what nothing less than one hundred pounds can effect."

"No. 100: Upon so potent a help as these two last-mentioned inventions, a waterwork is, by many years' experience and labour, so advantageously by me contrived, that a child's force bringeth up, an hundred feet high, an incredible quantity of water, even two feet diameter. And I may boldly call it *the most stupendous work in the whole world;* not only with little charge to drain all sorts of mines, and furnish cities with water, though never so high seated, as well as keep them sweet, running through several streets, and so performing the work of scavengers, as well as furnishing the inhabitants with sufficient water for their private occasions; but likewise supplying the rivers with sufficient to maintain and make navigable from town to town, and for the benefit of lands all the way it runs; with many more advantageous, and yet greater effects of profit, admiration, and consequence; so that deservedly I deem this invention to crown my labours, to reward my expenses, and make my thoughts acquiesce in way of further inventions; this making up the whole 'Century,' and preventing any further trouble to the reader for the present, meaning to leave to posterity a book wherein, under each of these heads, the means to put in execution and visible trial all and every of these inventions, with the shape and form of all things belonging to them, shall be printed by brass plates."

Mr. Partington, in his edition of the "Century of Inventions," then notes: "The last three inventions may justly be considered as the most important of the whole *Century*, and when united with the 68th article they appear to suggest nearly all the data essential to the construction of a modern steam-engine." The noble author has furnished us with what he calls a "definition" of this engine. It is exceedingly rare, as the only copy known to be extant is preserved in the British Museum. It is printed on a single sheet, without date, and appears to have been written for the purpose of procuring subscriptions in aid of a water company then about to be established:—

"A stupendous or a water-commanding engine, boundless for height or quantity, requiring no external nor even additional help or force to be set or continued in motion, but what intrinsically is afforded from its own operation, nor yet the twentieth part thereof. And this engine consisteth of the following particulars:—

"A perfect counterpoise, for what quantity soever of water.

"A perfect countervail, for what height soever it is to be brought unto.

"A *primum mobile*, commanding both height and quantity, regulator-wise.

"A vicegerent or countervail, supplying the place and performing the full force of men, wind, beast, or mill.

"A helm or stern, with bit and reins, wherewith any child may guide, order, and control the whole operation.

"A particular magazine for water, according to the intended quantity or height of water.

"An aqueduct, capable of any intended quantity or height of water.

"A place for the original fountain or river to run into, and naturally of its own accord incorporate itself with the rising water, and at the very bottom of the aqueduct, though never so big or high.

"By Divine Providence, or heavenly inspiration, this is my stupendous Water-commanding Engine, boundless for height and quantity.

"Whosoever is master of weight is master of force; whosoever is master of water is master of both; and, consequently, to him all forcible actions and atchievements are easie."

Lord Worcester's engine was exhibited in operation in the year 1656, when the Grand Duke of Tuscany visited England, at which time the marquis was a close prisoner in the Tower. It was shown at Lambeth, as thus recorded in the Grand Duke's diary: His Highness went "beyond the Palace of the Archbishop of Canterbury to see an hydraulic machine, invented by my Lord Somerset, Marquis of Worcester. It raises water more than forty geometrical feet by the force of one man only; and in a very short space of time will draw up four vessels of water through a tube or channel not more than a span in width."

It was, until of late years, asserted by the French that Lord Worcester took the idea of his engine from De Caus, engineer to Louis XIII.; but the only evidence was a letter, written to suit an engraving originally designed to illustrate a tale of fiction, and this letter has been conclusively proved to be a forgery. Dr. Lardner has suggested that in the contrivance attributed to De Caus only one vessel was employed; whereas in Lord Worcester's contrivance steam was employed in the same manner as in the engines of the present day, being generated in one vessel, and used for mechanical purposes in another, upon which depends the whole practicability of using steam as a mechanical agent (see "Wonderful Inventions," 1868). Professor Millington has designed an engine on similar principles to those of Worcester's engine, which, with a few alterations, might be made available for the same purposes. Professor Millington's design is engraved and explained in Partington's edition of the "Century." Among the drawings in the Patents Museum at South Kensington is "No. 75. Coloured Drawing of the Marquis of Worcester's Steam-engine, 1663."

CHEMISTRY OF THE FINE ARTS.—III.

By Professor Church, Royal Agricultural College, Cirencester.

CHEMISTRY OF FIXED DRYING OILS—VOLATILE ESSENTIAL OILS—NAPHTHA, PETROLEUM, PARAFFINE—AMBER, DAMMAR, AND OTHER RESINS—VARNISHES.

In using the pigments which have been described in the two preceding lessons, it is necessary to employ some substance which will at once give coherence to the particles of colour amongst themselves, and cause them to adhere to the wall, canvas, paper, or other surface to be painted. This substance is usually a liquid or a solution, and is generally called a *vehicle* or *medium*. However, it does something more than keep the particles of pigment in their places, for it possesses a more or less complete protective power, preserving the colours used from injurious atmospheric influences. We shall first describe some of the most important materials employed in the processes of oil painting and similar methods, and amongst these the fixed drying oils claim attention in the first place.

Fixed oils are distinguished from the volatile or essential oils by the permanence of the clear stain on paper which they make. But the oils suitable for painting are not only fixed, but drying; that is, the clear stain on paper, just mentioned, becomes hard and ceases to be greasy after the lapse of a little time. This hardening is attended by the absorption of oxygen, and is known as resinification. It takes place more rapidly the purer the oil; and as the same methods of purification are applicable, to a great extent, to all the drying oils used in painting, we may devote a few words to such methods before giving a brief description of the several oils.

If a drying oil, such as linseed, be boiled alone, it thickens, becomes darker in colour, and if spread in a thin film dries more rapidly than in its original state. But the process is greatly shortened and improved by the addition of certain materials to the oil, such as white lead, litharge, black oxide of manganese, manganese sulphate, or roasted white vitriol, *i.e.*, zinc sulphate. Lead compounds have a tendency to unite with part of the oil, which consequently contains lead in solution, and as this will be darkened readily by many sulphur compounds, the use of lead compounds in the preparation of oil for pictorial use is not desirable; the dry sulphates of zinc or manganese are far preferable, and, when warmed with suitable oils, yield admirable preparations almost free from colour. Occasionally water has been used along with these sulphates. But it may be stated that where rapid drying qualities are not required so much as a pure and colourless oil free from rancidity (which betokens the presence of a free acid), then the following plan may be employed:—The oil is to be shaken up at intervals in a large bottle with twice its bulk of pure water, a little common salt or alum, and some fine white silver-sand. When the oil has separated from the aqueous liquid it is to be syphoned off, or turned into a separating funnel, and the washing process repeated on it with fresh water, sand, and salt; this must be done over and over again, until the wash-water remains clear. Finally, the oil, from which the mucilage has been now completely abstracted, is filtered through warm freshly-burnt bone-black, which removes at once moisture and the last traces of colour. Other methods of purifying oil are these:—Boil for two hours 1 gallon of oil, skim it, then add 100 grains of calcined magnesia, and boil again. Mix 3 lb. of oil with a quart of alcohol, and keep the mixture in a warm place.

The fixed drying oils, when pure, consist essentially of combinations called glycerides. These are compounds of the residue of glycerine, with the residues of about three or four different acids, such as linoleic, stearic, and palmitic. In other words, they contain glycerine, in which the three atoms of replaceable hydrogen, $C_3H_5H_3O_3$, have been replaced by the several radicles of these acids. These compounds admit of several isomeric modifications, especially under the influence of heat, and are easily decomposed into glycerine and soaps by alkalies. The drying oils may be identified by several reactions, which may be further used to detect any considerable admixture of non-drying oils with them. When, for instance, one part of red, nitric acid, or of nitric acid in which mercury has been dissolved, is shaken up with twelve parts of a non-drying oil, such as olive, the whole becomes solid in an hour or two; but the presence of poppy or nut oil in traces retards this solidification, and in larger quantities prevents it. As a rule, then, we may say, that nitric peroxide does not solidify the true drying oils. Oil of vitriol gives out much more heat when shaken with these oils, than when shaken with those which do not dry.

The relative merits of the several drying oils in use are not satisfactorily determined. Linseed is, indeed, most commonly employed, especially in this country, but it is a question whether poppy and nut oils do not harden more uniformly than linseed, and without forming a surface skin or pellicle. In all cases, and with all drying oils, the cold-drawn oils are superior to those which have been extracted by heat and pressure combined, and which are found to contain abundance of mucilaginous and nitrogenous matters very injurious to the quality of the oil. Some recent methods of extracting oils by the use of solvents, such as carbon disulphide (bisulphide of carbon) and mineral turpentine, yield excellent products, which, when purified as before related, are quite fit for use in painting.

The following table gives the names, sources, specific gravity, and solidifying points of the seven best drying oils:—

NAME.	ORIGIN.	SPEC. GRAV.		SOLID. POINT.
Linseed oil	Seeds of Flax, *Linum usitatissimum*	·935	*minus*	20°C.
Nut oil	Walnut, *Juglans regia*	·929	,,	18°C.
Poppy oil	Seeds of Poppy, *Papaver somniferum*	·927	,,	18°C.
Hemp oil	Seeds of Hemp, *Cannabis sativa*	·931	,,	28°C.
Fir-seed oil	Seeds of Pine, *Pinus sylvestris*	·931	,,	30°C.
Sunflower oil	Seeds of Sunflower, *Helianthus annuus*	·925	,,	16°C.
Gold of Pleasure oil	Seeds of *Camelina sativa*	·931		19°C.

Of the above oils, those of linseed, hemp, and walnut have, at the same temperature, 19° C., about the same degree of fluidity, which is only $\frac{1}{10}$ of that of pure water, while poppy oil is the least fluid of all, being represented by the number 73, if water be taken at 1000. In per-centage composition the same oil varies somewhat in the proportions of its three elements, carbon, hydrogen, and oxygen, according to the proportion of its constituent glycerides; but the usual numbers are fairly represented by the per-centages—carbon 78, hydrogen 11·5, oxygen 10·5. The fixed drying oils mingle readily with benzole, spirit of turpentine, mineral turpentine, and ether, but are only partially soluble in cold spirits of wine.

The essential oils applicable for painting are far from numerous, while those actually employed are two only, those of turpentine and spike. It may be advisable to say a few words on the distinctive characters of essential oils, before describing the preparation and properties of those with which the painter is more particularly concerned. Essential oils are all volatile when freshly prepared; indeed, their method of preparation, usually distillation, involves this. But they differ remarkably in composition, some being hydrocarbons, containing therefore nothing but carbon and hydrogen; others containing oxygen as well; and a third series containing sulphur, and sometimes nitrogen, in addition to carbon and hydrogen. But the painter has to do only with the first series of these essential or volatile oils, which contain a hydrocarbon as their main ingredient, and which are nearly always represented by the formula, $C_{10}H_{16}$: a formula which corresponds to these per-centages:—

Carbon	88·2.
Hydrogen	11·8.

Still it will be found that a small quantity of oxygen is always present in these oils, partly because they contain along with the hydrocarbon of which they mainly consist, another substance, usually a camphor or stereoptene often having the formula $C_{10}H_{16}O$; and partly because they have a strong tendency to unite with oxygen, and to become resins. In doing so they at last become acid to test-paper, thick and viscid, and at the same time acquire a yellow or brown colour of varying intensity of tone. Further, when they become quite dry they are brittle, though possessing some degree of hardness. The absorption of oxygen then, attended as it is by the changes just mentioned, is the great drawback in the use of essential oils in painting: we shall presently see how it may be obviated. Yet it must be recollected that this tendency to absorb oxygen is not without its advantages. Turpentine which has absorbed oxygen becomes ozonised, acquiring, for a time at least, some bleaching properties. As an example of this fact, note the colour of a cork which has been some time in a turpentine bottle. Now this ozone may be transferred to the oil of the pigments used in a painting, and may serve to harden and resinify them before the pigmentary particles have had time to be injured by atmospheric influences. The use of freshly distilled spirit of turpentine, which has been shaken up in a bottle three parts full of air, repeatedly renewed, suggests itself as a way of utilising the several properties of the liquids just alluded to. Volatile oils mix readily with alcohol, especially if absolute, with ether, with petroleum, and fixed oils; while they dissolve fats and many resins. A few words only on the preparation of essential oils must suffice, while we will take, as at once characteristic and important examples of these materials, the oils of turpentine and spike lavender. In order to prepare these hydrocarbons in a state as little altered as possible, the materials which contain them are distilled with water, or with salt and water, or in a current of steam. In the case of turpentine, dry distillation is also resorted to, especially after the bulk of the oil has been driven off. Turpentine, as it exudes from pine and fir trees, or as it is obtained between May and October from incisions in their barks, is a mixture of hydrocarbons and their resinified products of oxidation. In distillation the essential oil is volatilised and condensed, while the residue becomes hard, and goes under the name of rosin or colophony; it chiefly consists of an acid resin. In the case of spike lavender oil, distillation with calcined magnesia or lime can hardly be resorted to, in order to purify the product, without entailing much loss; but oil of turpentine may be submitted to this treatment. Oil of turpentine may also be purified by agitation, in a vessel kept cold, with 5 per cent. of oil of vitriol, and the subsequent distillation of the reddish thick liquid which is thus obtained. This liquid should have been previously allowed to settle, and then decanted from any deposit. An oil is obtained in this way, called terebene by Deville, and but little prone to oxidation.

The turpentine oils of commerce are:—

NAME.			SOURCE.
English Turpentine oil			*Pinus Australis*, etc.
French	,,	,,	*P. maritima.*
German	,,	,,	*P. sylvestris*, etc.
Venetian	,,	,,	*Larix Europœa.*
Pine-cone	,,	,,	*Pinus pumilio* and *Abies pectinata.*

These oils differ much from one another in optical character, but chemically their divergences are but slight. They boil at 160° Cent., when purified completely from acid and resinous impurities, etc., and their specific gravity is about ·860. The oil of lavender is a foreign oil, derived from *Lavandula spica*, or spike lavender, and though inferior in odour to that from *L. vera*, our English lavender, is better adapted for painting. It is a far more powerful solvent for resins and similar substances than oil of turpentine. Other hydrocarbon oils of similar properties are those of bergamot, lemon, juniper, orange, and rosemary. It is probable that some of these oils are worthy of further trials in painting than those to which they have yet been submitted. All the oils of the lemon group are less volatile than turpentine, boiling at 175° C. instead of 160°; but their specific gravity is a little lower, about ·850 instead of ·860.

Before passing on to a brief description of the chief resins, we may here appropriately introduce a class of hydrocarbons, scarcely hitherto actually employed in painting, and yet likely to prove of very great service in the arts. We refer to the natural and artificial naphthas and petroleums, and their liquid and solid products. Mineral turpentine is the commercial name given to the "spirit," or most volatile portion of native rock oils, or of the artificial paraffines prepared from coals and shales by distillation at a low and regulated temperature. It is a mixture of hydrocarbons, very inflammable and volatile, and possessing remarkable solvent powers for resins, yet with small tendency to absorb oxygen. The four simplest of these hydrocarbons are gases at ordinary temperatures, while those which make up a good part of the mineral turpentine boil at temperatures from 30° upwards. The liquid boiling at this point is called quintane, and has the formula C_5H_{12}. The four or five next members of the series, boiling at temperatures up to about 160°, may be used as substitutes for oil of turpentine for many purposes. Here also we may allude to solid paraffine, a name given to a mixture of hydrocarbons occurring in shales, rock oils, etc., or obtained from them and from peat, lignite, coal, etc., by cautious distillation. The best paraffine for the artistic purposes to which we shall subsequently refer, has a melting-point not under 58° C., and is entirely unacted upon or reduced in weight by treatment with boiling soda solution, or warming with oil of vitriol up to 100° C. Its unalterable nature has induced the writer of these papers to employ it in mural decoration and for other artistic purposes, since the year 1859, and with the most satisfactory results. We shall describe some of the modes of using it in a subsequent lesson on the processes of painting; but we may now state that it is soluble in about three parts of hot absolute alcohol, but separates on cooling; that it may be dissolved in mineral turpentine, benzole, turpentine, oil of spike, and fixed oils; and that Young's best paraffine and Field's best ozokerit are available sources of it for our present purpose. Light coal naphtha, obtained as a by-product in the distillation of coal-gas, must be distinguished from the substances just named. It chiefly consists—when freed from carbon disulphide and heavy impurities—of hydrocarbons of the benzole series, of which the most important is perhaps the first; benzole or benzine (C_6H_6), a liquid of density ·885, freezing at 3°, and boiling at 81° C. When pure, this liquid has no disagreeable smell; commercial samples of it are greatly improved in this particular by being shaken up with 5 to 10 per cent. oil of vitriol for some days, decanted off and distilled from a water-bath in a tin can and with a properly-cooled condenser. Benzole mixes with absolute alcohol, and is an admirable solvent for many resins, oils, and similar materials, but its place may to a certain extent be supplied by the next member of its series, toluole, a hydrocarbon which, with several others, accompanies it in coal-naphtha, and boils at 111°C. The higher members of the series, xylole, etc., do not evaporate with sufficient rapidity, when used with resins, oils, and paraffines.

The resins may now engage our attention. They are essentially, in origin and composition, oxidised essential oils, containing less hydrogen than these latter, and oxygen in addition. They differ greatly in physical and chemical properties. The best are those which are most free from colour, tough, hard, and destitute of distinct acid characters. These resins, however, are usually the very kinds which it is most difficult to bring into solution, so as to form varnishes. Generally, the most soluble resins are those which are most prone to change, becoming brittle and brown in course of time. We shall arrange what we have to say about the most important resins under their several names, taken in alphabetical order.

Amber is a fossil resin, and one of the most useful and least alterable of all. One of its classic names, *berenice*, preserved in the German word for amber, *bernstein*, has originated the terms vernice, vernix, vernis, and varnish; this resin having been originally used in the preparation of a varnish, by boiling it in oil. Amber has the hardness 2·5, the specific gravity 1·065. It is insoluble in alcohol, and nearly so in most fixed and essential oils, but may be dissolved in chloroform, and in some of the other powerful solvents which we have before alluded to. It makes an excellent varnish, the colour of which may be lessened by agitation with a small quantity of calcined magnesia.

Animé.—This name is often used for some varieties of copal resin, but it appears should be confined to the resin of the *Hymenæa Courbaril*, from the West Indies and Brazil. This is the copal or *animé tendre* of the French, and is largely employed in the manufacture of carriage varnishes. It is of specific gravity 1·03, and is soluble in hot alcohol. It is not a very hard or permanent resin.

Copal is a most valuable resin, furnished by many countries, and the produce of many trees. The different varieties of it met with in commerce are not all of equal value, but in composition they seem almost identical, generally containing in 100 parts about 80 of carbon, 10 of hydrogen, and 10 of oxygen. Copal comes from North America, East Indies, Madagascar, and Sierra Leone. Its density varies from 1·045 to 1·139, while its solubility in turpentine and oils is very slight, unless it has been previously fused, or at all events roasted. It may, however, be more easily dissolved in the presence of camphor, or at a higher temperature than that, obtainable in an open vessel. In a sealed tube, copal dissolves pretty freely in camphorated turpentine at temperatures below 200° C. The advantage of this mode of preparing copal varnish over that usually pursued, of torrefying the copal previously to heating it with the linseed oil or turpentine solvent, lies in freedom from colour and oxidised products, and in greater toughness. True copal is hard, rather variable as to colour, and as to the form of the masses in which it occurs. Pulverisation and exposure to air render it more easily soluble.

Canada balsam, from *Abies balsamea*, is a resinous turpentine, which may be dissolved in oil of turpentine to form a clear and colourless varnish. It is in great part soluble in alcohol, the solution drying, when used as a varnish, in the course of a day or two.

Dammar is chiefly obtained from Singapore, but a variety is also yielded by *Dammara Australis*, a New Zealand tree. The East Indian dammar requires to be crushed and gently dried to make a clear varnish, and will then be found to be soluble to the extent of 80 per cent. in absolute alcohol, and entirely in the liquid hydrocarbons and fixed oils. A fine colourless varnish may be made by leaving the crushed Australian dammar resin, often called "kouri" or "cowdie" gum, in contact with weak alcohol for some days, shaking the mixture occasionally, and then pouring off the liquid, which is a solution of the acid resin of the dammar. The remaining substance is the neutral resin, which when dissolved in absolute alcohol, turpentine, or other similar solvent, forms a beautiful colourless varnish, yet does not approach the best copal varnish in toughness and permanence.

Mastic, from Chios, in the Grecian Archipelago, is obtained by incisions made in a tree, the *Pistacia lentiscus*. Its density is 1·07; it occurs in the form of nearly colourless and transparent tears, and is soluble in alcohol as well as oil of turpentine, forming a rapidly-drying but alterable varnish, which becomes brittle and dark-coloured by age.

Sandarach was used almost exclusively in mediæval times as the basis for the varnish of tempera pictures, and of the vehicle of oil-painting. It is not a satisfactory resin; it is the produce of the *Thuja articulata* of Barbary. It occurs in pale yellow scales, slightly acid and soluble in great part in alcohol.

Shellac is produced in Assam, and many parts of India, from a tree called *bihar*, by the puncture of an insect, the *Coccus laccæ*. When purified it occurs in yellow or brownish scales, and is brittle, and easily soluble in many acids and alkalies. It dissolves in alcohol, fusel oil, and in 1½ parts of acetone. A white or bleached shellac is often made by bleaching 25 parts of shellac in alkaline solution, with the sodium hypochlorite from 30 parts of good chloride of lime, and then adding hydrochloric acid, exposing to the sun, and allowing the mixture to stand. Afterwards some sodium sulphite is added, and the resin finally precipitated with hydrochloric acid. Sulphurous acid is also used for the same purpose, but the only plan permissible for bleaching shellac intended for artistic purposes is filtration of its solution through animal charcoal.

We have been compelled to omit several resins and vegetable waxes from our list. Such are the various resins known as dragon's blood, and used in red varnishes and lacquers, and Chinese and Japan wax.

CIVIL ENGINEERING.—XII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

DOCKS (*continued*).

A FLOATING dock is more useful than an excavated dry dock because it can be employed *anywhere* irrespective of the nature of the bottom, whether it be sand, mud, or rock, the only condition necessary to its use being that a sufficient depth of water exists to float the ship which has to be raised, together with the dock in its submerged condition beneath the keel of the ship. In this point of view it is plain that the *shallower* the dock the better; hence, provided an ordinary closed pontoon fulfils all conditions necessary to ensure stability in equilibrium, and retain a horizontal deck, whether submerged or floating with its burden, nothing can be better as respects light draught.

The necessary condition to stability in a floating dock is that it shall have a sufficient amount of ballast at its lower portion to remain vertical under all circumstances, the ballast employed in all cases being water. The usual form of such a dock is that of a long open-ended box or half-cylinder, provision being made, however, for fixing water-tight bulkheads or ends if required. Whilst the main power of flotation lies in the lower portion of the dock, it is necessary that the raised sides should also contain an amount of flotation, and it is in the distribution of this power, by altering the position and quantity of water by means of pumps, that the dock retains a horizontal floor or deck in all conditions.

The sectional floating dry dock at the United States navy yard at Philadelphia will engage our notice in the first instance. As its name implies, it is formed of *sections*. These are nine in number, and any number can be used which may be required for the length and weight of the vessel to be raised. Each section is 148 feet long and 11 feet deep outside, but six only are 32 feet wide, the remaining three being only 30 feet wide. There are also two end floats each 26½ feet long, 20 feet wide, and 8½ feet deep, adapted to the larger sections, and two somewhat smaller for use with the smaller sections.

The tanks in the sections are of timber, the bottom and ends being of white oak, 4 inches thick; the sides and top of yellow pine, the sides 5 inches thick, the top 3½ inches thick. The planks of which they are built are from 12 to 15 inches wide. Each plank is fastened with two iron spikes 9 inches long, and 7$\frac{1}{16}$ inches square, to each beam at the point of crossing.

The entire structure is throughout of timber strengthened with iron braces, and considerable ingenuity was displayed in the bracing; and the fact that these timber-built docks have not proved successful, must be attributed rather to the unsuitableness of the material than to the mode of construction. The various sections are arranged side by side, and as each section has a greater power of flotation than is needed for the corresponding length of run of any ship placed across it, an economy in pumping has been introduced by separating the various sections by means of a sliding or telescope arrangement of beams at distances varying from 6 inches to 6 feet as may be required; thus a greater length of run of ship will lie between the centres of any two adjacent sections the more they become separated, and hence each section will have a greater weight to support. For heavy vessels 3 feet is far enough to separate the sections, this being the usual distance apart at which keel-blocks are placed. Each tank except the centre one has a door at either side for facility of passing from one section to another. The tanks are carefully caulked, tarred, pitched, and made water-tight. Inside them are longitudinal and transverse truss-frames so arranged as to afford the requisite strength for raising the heaviest vessels. In Fig. 25 we show the arrangement of the timbers of one of the interior trusses.

Perpendicular to the line of keel-blocks, bilge-blockways are fastened to the deck upon which the bilge-blocks slide. These ways are fitted with teeth, into which drop iron falls hinged to the back of the blocks, by which the blocks are secured at the point of bearing. The arrangement is shown in Fig. 26. The line A B in Fig. 25 corresponds with the line A B in Fig. 26.

The tanks are graduated to feet and inches to indicate the depth of the keel-blocks below the surface of the water. Gauge-rods are fixed, showing the quantity of water pumped, and therefore the lifting power exerted by each section, and thus is obtained the weight of the vessel on the dock. The full lifting power of the dock is as follows:—

	ft.		ft.		ft.		
6 sections	105	×	32	×	11	=	6,336 tons.
3 „	105	×	30	×	11	=	2,970 „
6 end floats	26·5	×	20	×	5·5	=	500 „
3 „	24·5	×	20	×	5·5	=	231 „
Displacement						=	10,037 tons.
Weight of tanks and machinery						=	4,145 „
Lifting power						=	5,892 tons.

Horizontal shores extend from each side frame. They work upon hinges at the point of bearing on the frames, and are fitted with a sliding telescopic arrangement, so as to suit themselves to the varying widths of the vessels they have to support. These shores keep the ship in the centre of the dock until the keel and bilge blocks are brought to bear.

The pumping arrangements of each section are controlled by four engines—two of 20 horse-power each, and two of 12 horse-power each. There are three pumps at each end of each section; the shafting which conveys the power from one section to another runs in a hollow sliding shaft, and may be slid in or out as required by the relative position of the sections. Between each section is a universal joint to provide against the deflections incident to the sectional arrangement.

In connection with the sectional dock is a system of land rails brought close to the water's edge, their ends corresponding flush with similar rails on the floating sections. By means of these a vessel can, when required, be removed from the sectional dock to the shore, the sections being sunk by the introduction of ballast to an exact level with the ways on shore. Hydraulic power is employed to move a vessel on or off the ways. The ram employed has a stroke of 8 feet, the cylinder being keyed to the rail when in action. As soon as the ram has gained its full stroke, the same engines which are employed in forcing the water into the cylinder, are used to move the cylinder forward another 8 feet. The ram is capable of urging forward a ship upon the ways at the rate of 1 foot per minute, and twelve minutes are occupied between each successive stroke of 8 feet. After a vessel has been standing on the shore-ways for a few days, it requires about 25 per cent. more power to push it back to the dock than to haul it on shore. The cylinder has a bore of 15 inches, and can exert a force equivalent to 800 tons lift.

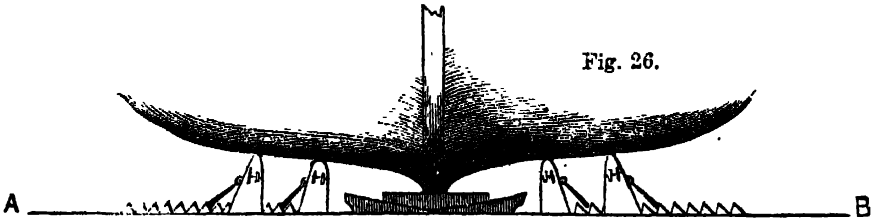


Fig. 26.

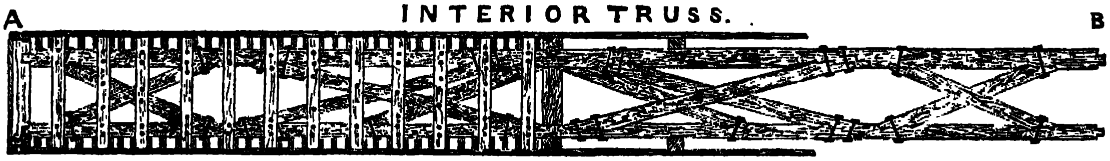


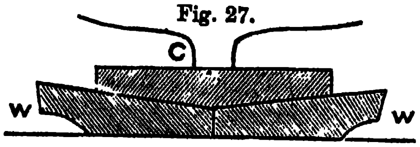
Fig. 25.

Another form of floating dock is the *balance* dock, in use in various ports of the United States. This is not merely a caisson dock, but may be described as a combination of the caisson and camel united in the form of a walled dock, having a middle compartment in which the vessel rests after the water is pumped out. The combination is made by butting the side compartments or balancing chambers—which rise considerably above the floor of the dock—with sloping inner walls, into a caisson, and giving to the structure great strength and massiveness by interwoven bracing and trussing both transversely and longitudinally. The portion of the sides extending above the windows or ports which occupy a horizontal line upon each side of the dock, is called the ballast chamber, and as the dock is almost entirely constructed of yellow pine timber, it will not sink by its own specific gravity low enough to admit vessels of great draught; it has therefore to be sunk by filling the upper or ballast chambers with water. When ships of great weight have to be lifted, it is necessary to use end or enclosing gates. These are formed of yellow pine strongly braced with iron.

To dock a vessel in the balance dock, water is forced into the bottom of the dock, and then into the upper chambers until its weight acts as ballast to sink the dock as much as required. When the ship is in the dock and in position to be raised, the ballast is run off by opening valves in the lower side chambers, thereby causing the dock to rise by its own specific gravity until it touches the bottom of the ship; the remainder of the water is then pumped out, and the dock rises with the ship. The advantage of the balance dock lies in the facility with which an exact equilibrium and level can be maintained by means of water let into or pumped out of the separate compartments of either of the side chambers, there being eight of these compartments in each side chamber, which all communicate with a pump-well in the centre of the chamber by means of valves. The advantage of dividing a floating-dock, whatever be its form, into numerous bulkheads is proved both in theory and practice, and it may be stated as a general fact that the tendency of a dock to capsize is inversely as the square of the number of separate compartments into which it is divided by bulkheads.

The necessity for examining the whole run of the keel of a ship upon the under side, and frequently of having to renew a portion, involves the necessity of removing when required any one of the keel-blocks upon which her weight rests. This was formerly a long and tedious process, the plan being to throw her weight upon the side shores by introducing wedges under each shore, the blows being given to them simultaneously. In this way the vessel was slowly raised off her keel, and the bearing transferred to the shores. The necessity for *simultaneous* action in driving home the wedges involved a very large number of men, and instances have occurred of the entire hands employed in a yard being compelled to leave their various employments in order to wield the sledge hammers for this operation. To prevent this loss of time and labour, Mr. (afterwards Sir Robert) Seppings suggested the idea of a new arrangement of keel-block. The idea is so exceedingly simple, that it is to be wondered how so obvious an arrangement had not occurred to any one connected with ship-building long before. The arrangement is shown in Figs. 27 and 28. In these c is a hard wood block having its upper and under sides lined with iron; the angle at the base is 170°. w, w are cast-iron wedges, the upper and under sides sloping to an angle of 5°. The blows for removing the wedges are given laterally as indicated by the arrows, and are delivered on alternate sides, and by this means the wedges are readily removed. Of course only one intermediate support can be removed at a time, but the wedges are easily replaced, and the next support then removed. This very simple arrangement secured for the suggester £1,000 from the Admiralty. There can be no doubt as to the superiority of iron over wood as the material for building a floating dock. Superior to it in strength, it occupies far less bulk, and is with proper care and attention far more durable. An iron dock may be considered as partaking of the same form as the ship it is intended to enclose, since the plates of which it is built can be curved to any desired shape. Looking at an iron floating dock as a semi-tube, its great weakness lies in the fact that it is unsupported by braces. It is in the connection between the inner and outer skins that a great portion of its strength lies, for although it may be regarded as one entire frame, yet like all large iron structures, especially those in which the principles of *hollow* construction are adhered to, it must be looked at from every individual point. Notwithstanding that the strength of a girder is directly as its depth, yet by an unscientific arrangement of material, it may fail locally long before the actual breaking strain is reached. There is no real difficulty in disposing of the material employed, so that an ample amount of strength shall be secured to meet every strain in every direction, and it is due very frequently to a want of scientific knowledge in the arrangement of the material, whether employed as ties or braces, that failure ever occurs. An open-work or lattice bracing is without a doubt the proper method of obtaining the greatest strength with the least weight and expenditure of material, provided always that the various pieces composing it are properly connected. With respect to the employment of lattice-work it has very correctly been stated, that by means of it the engineer is not only enabled to place the material exactly where it is wanted—*in the very line of strain, as it were*—but he is also certain that, when it is correctly placed, the strains *must* pass in the direction marked out for them, and *cannot* take another; whereas when solid plates are used, there is always some ambiguity respecting the precise direction of the strain, and more faith is in such a case put in the mass of the plates, than in the strength of any particular part of them. We shall have occasion to call closer attention to the use and value of lattice-work when we treat of *bridges*.

Fig. 27.



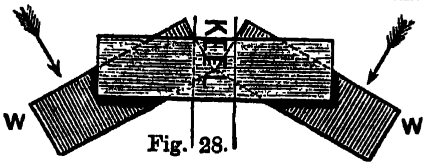


Fig. 28.

We have alluded to the value of lattice-work here, because it has been employed with great advantage in the construction of a floating dock built for Callao a few years since. It was constructed in this country in sections, and sent over and put together. In section it is rectangular, the sides being vertical, and very strongly braced at the inner angle. It is 300 feet long, 76 feet broad inside, and 30 feet deep inside, and weighs about 3,000 tons. The available floor is 50 feet wide, and the slope, which has a batter of 1·25 to 1, has a vertical height of 9 feet. There is a space of 12 feet between the inner and outer skins, in which lies the power of flotation. Water-tight bulkheads are introduced, thus diminishing the tendency to capsize. Transversely there are six water-tight bulkheads which run across the entire section, dividing the dock into seven separate transverse chambers, whilst longitudinal bulkheads, running the whole length of the dock, again subdivide these. The skins are of ½-inch boiler-plate, and there are transverse strengthening girders throughout the dock 5 feet apart, and 9 feet in depth, carried up in the form of lattice-work through the side water-compartments, air-chambers, and horizontal bulkheads.

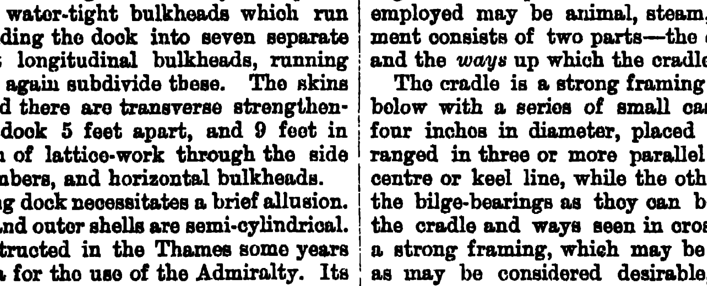
Another form of iron floating dock necessitates a brief allusion. It is that in which the inner and outer shells are semi-cylindrical. A dock of this form was constructed in the Thames some years since, and floated to Bermuda for the use of the Admiralty. Its dimensions and power are sufficient to dock the largest iron-clad. In length it is 381 feet, in outside breadth 124 feet, and in depth over all 72 feet. The space between the two skins is 20 feet. Instead of the sides being vertical, they are curved outwards with a batter of 1 in 6, but become more nearly vertical towards the top. The skins are of ½-inch boiler-plate, and the space between them is divided into fifty water-tight compartments. Seven water-tight bulkheads run throughout the entire length of the dock, whilst the frame is held together by nine transverse box-ribs also water-tight. Vertically the dock is divided into three stages, the upper chambers, the middle or balance chambers, and the lower or air chambers. In order to dock a ship, the water is pumped from the lower to the upper chambers, until the dock sinks sufficiently to permit the ship to enter at the open end, and be brought over the line of blocks. The water is then run out of the upper chambers, until the dock rises about 10 feet. Floating caissons made to fit the ends are then submerged into their position, and as much of the remainder of the water as is necessary is then run down into the air-chambers, to be again pumped up when required. In order to careen the dock for examination or repair, water is introduced into one side only, by means of which any required angle of inclination is obtained. About 8,000 tons of iron were employed in its construction.

Another system of dry-docking ships has been adopted, of value, however, in suitable localities only. In order to carry out this system, it is necessary that the ground has a certain amount of incline from the water's edge, and that a natural supply of land-water exists at the upper portion of the slope. The arrangement consists of a series of three or more basins formed in the slope, rising one above another in successive altitudes of from six to ten feet, and communicating with each other by ordinary lock-gates, similar precisely to the lock-basins of a canal. The lower basin opens directly into the harbour, and the depth over the sill must be such as that the vessel to be docked can float over it into the lower or No. 1 basin. When the vessel is within this basin, the outer gates are closed, and the land-water admitted into it until the vessel rises on a level with the water in No. 2 basin; the vessel is then floated into it, and the sluice-gates closed. The same process then follows with regard to the other basin or basins, and finally the whole of the water is withdrawn from the upper basin, and the vessel left high and dry upon the bearing blocks. The vessel is lowered to the harbour by reversing the operation.

We come now to the last method employed for dry-docking ships—that of hauling them up prepared ways by sheer force. This system was practised at an early period in the Venetian arsenals, and also at Toulon, where a large vessel was so docked as far back as 1818. The plan is adopted in many places where the ground favours it, the essential feature being that of a gradual and uniform slope both above and below the water's edge. The slope should be about 1 in 32, and the power employed may be animal, steam, or hydraulic. The arrangement consists of two parts—the *cradle* on which the ship rests, and the *ways* up which the cradle is drawn.

The cradle is a strong framing of iron and timber, furnished below with a series of small cast-iron rollers, about three or four inches in diameter, placed at short intervals apart, and ranged in three or more parallel rows, one row occupying the centre or keel line, while the others are usually placed as near the bilge-bearings as they can be.* Fig. 29 gives a sketch of the cradle and ways seen in cross-section. The cradle, C C, is a strong framing, which may be extended breadth-ways as far as may be considered desirable, in order to afford sufficient space for planting shores. It must, however, be always remembered, that the cradle has to *transfer* the weight of the ship to the ways, W W, beneath, and therefore its structure must correspond with this idea. The employment of a large number of rollers is of advantage, as thereby the load is distributed over a greater number of points of support. The ways are made of timber, upon which are securely spiked iron rails. They are carried down into the water to a depth sufficient to enable a vessel to be floated over them. Great care is required in order to obtain a solid foundation for the timber ways, piles being necessary to support them, and to prevent any subsidence into the soft ground usually found at the water's edge. When a vessel is to be docked, she is floated over the cradle, and the bow or nearest end secured in position and wedged up by the bearing blocks. The cradle is then slowly hauled up the ways by attachments at the centre and sides, and as the vessel rises she is secured in position, and the bilge-blocks driven home. Pawls are fixed at various points of the centre frame, which fall into a rack fixed to the centre way to prevent any back-fall. The power required to haul a ship and its cradle up the ways, is about ·07 of the dead weight to be moved.

Fig. 29.



PRINCIPLES OF DESIGN.—XXV.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

GLASS (*continued*).

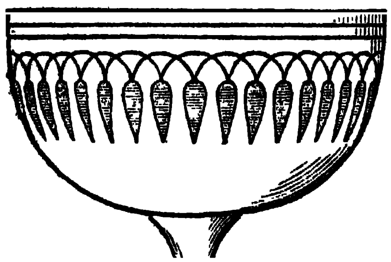


Fig. 116.

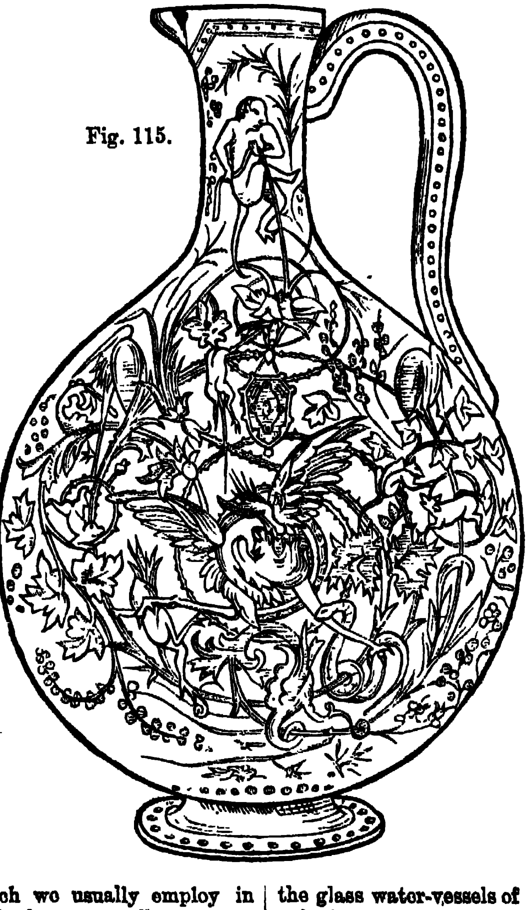


Fig. 115.

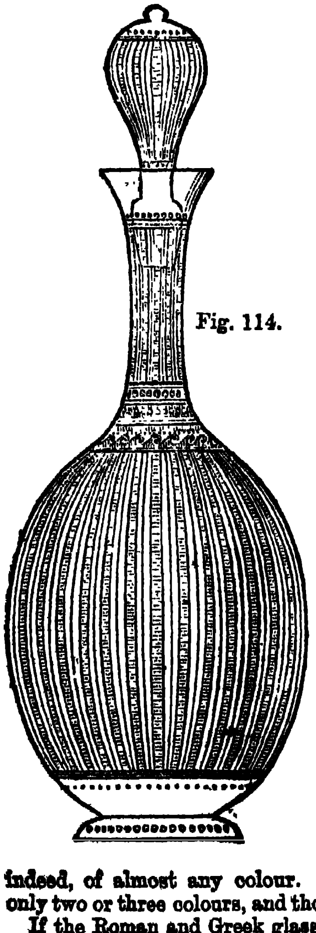


Fig. 114.

There is one thing pertaining to table-glass that we do not now sufficiently consider, which is its capacity for colour. Our one idea in the formation of glass vessels is the imitation of crystal, unless we happen to produce a vessel of the strongest tint. With the exception of hock glasses, which are generally either ruby colour, dark green, or intense yellow-green, we rarely employ tinted glass on our tables. These three colours, which we usually employ in hock-glasses, are all too strong in tint for ordinary purposes, and they are coarse and vulgar. It is curious that we should confine ourselves to these colours when glass is capable of assuming the most delicate of shades, of appearing as a soft, subtle, golden hue, of the most beautiful light tertiary greens, lilacs, and blues, and, indeed, of almost any colour. Why, then, should we employ only two or three colours, and those of the most crude character?

If the Roman and Greek glass of the British Museum be inspected, it will be seen that the Romans employed various soft and delicate tints, and why we should not do so likewise I cannot see. For many reasons the colours of our hock-glasses are highly objectionable, but especially for two. First, as already stated, the colour is so strong that they appear as mere dark spots on the cloth, and altogether fail in imparting to the table a pleasant colour effect; and, secondly, they utterly destroy the beauty of appearance which the wine would otherwise present.

No glass which is to contain a liquid of pleasant colour should be so strong in tint as to mar the beauty of the contained fluid, and especially is this true when the colour of the glass is of an opposite character to that of the liquid: thus a red liquid placed in a strongly-coloured green glass becomes highly offensive in appearance, and yet we often see claret served in green hock-glasses. A dinner-table requires colour. Let
pale-buff,
olour, in-
ite; and the glass water-vessels of very pale, but refined and various tints; and the salt-cellars, if of glass, also coloured, and a most harmonious effect could be produced. The flowers with which the table is adorned would then harmonise with the other things, and much beauty might be produced.

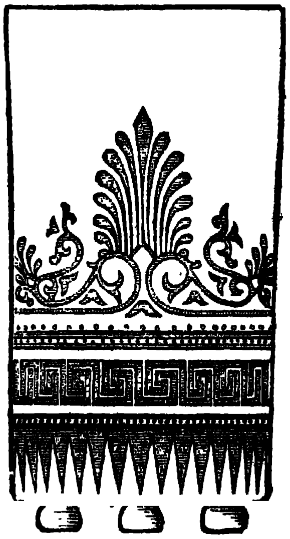


Fig. 117.

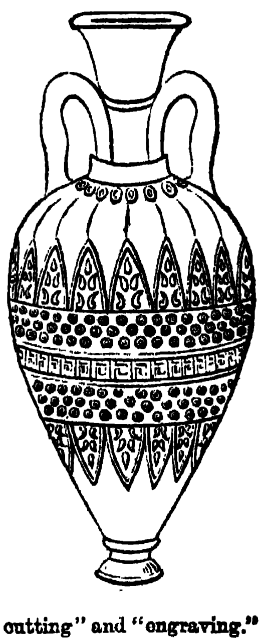


Fig. 118.

Respecting the ornamentation of glass, two modes of treatment are resorted to, which are "cutting" and "engraving." Both modes of treatment deal with glass as a hard, crystal-like substance; and consist in grinding the surface, and either leaving it "dead" or repolishing it. In the case of "cutting," a considerable portion of the substance of the glass is generally removed, and the surface is repolished; but in the case of "engraving" little more than the surface is generally acted upon, and the engraved portion remains dead.

Cutting may be employed in bringing about ornamental effects in glass, but it is rarely to be commended when so lavishly used as to be the chief means of giving form to the vessel; indeed, cutting should be sparingly and judiciously used. A vessel formed of glass should never be wholly shaped by cutting, as though it were a work of stone. If the neck of a decanter can be made more convenient by being slightly cut—if it can be so treated that it can be held more securely—then let it be cut; but in all cases avoid falling into the error of too much cutting, which causes the work to appear laboured, for any work which presents the appearance of having been the result of much labour is as unpleasant to look upon as that work is pleasing which results from the exercise of momentary skill. There is a great art-principle manifested in the expression "Let there be light, and there was light."

Engraving is also laborious, and while it is capable of yielding most delicate and beautiful effects, it should yet be somewhat sparingly used, for extravagance in labour is never desirable, and there is such a thing as extravagance of beauty.

However delicate ornament may be, and however well composed, yet if it covers the whole of the walls of an apartment and of the objects which it contains, it fails to please. There must be the contrast of plain surfaces with ornamented—plain for the eye to rest upon, ornament for the mind to enjoy. In the enrichment of glass these remarks fully apply. Let there be plain surfaces as well as ornamented parts, and the effect will be more satisfying than if all be covered with ornament.

All that I said respecting the decoration of damask table-linen will apply equally to glass, considering only the different way in which the effect is produced (see Vol. II., page 312). Thus we have ornament produced only by a variation of surface. Such simple means of producing an art-effect are capable of rendering in a satisfactory manner simple treatments only, but simple patterns are capable of yielding the highest pleasure, and such patterns can be almost perfectly rendered by engraving, as shown in Figs. 114,* 115, 116, 117, 118.

Somewhat elaborate effects can be rendered in glass by very laborious engraving, whereby different depths of cutting are attained, but such work is the result of great labour, and rarely produces an effect proportionate to the toil expended upon it; and if a bottle so engraved is filled with a coloured wine, the entire beauty of its engraving is destroyed. Fig. 115 is a drawing of a most elaborately engraved bottle which was shewn in the Exhibition of 1862. It represents, to a great extent, wasted labour.

It must be borne in mind that any ornament placed on a decanter, wine-glass, or tumbler, is to be seen almost wholly in perspective; and the remarks made respecting the effects of folded or waved surfaces on ornament (Vol. II., page 327), and those made in reference to the application of ornament to earthen vases (Vol. II., page 375), apply equally here.

It is not my province to enter into the various methods of manipulating glass, nor into all the classes of art-effect which glass is capable of yielding: I can only call attention to general principles, and leave the art-student to think for himself what should be the treatment of any particular object. There is a sort of crackle glass which has come into use during the last few years, and is an imitation of old Venetian work; this is in some respects pleasant in appearance, but it is somewhat uncomfortable to handle, and is difficult to keep clean; its use must therefore be limited.

In another chapter I shall have a few remarks to make upon stained glass; but as our present considerations pertain to hollow vessels chiefly, and as general principles regulate the formation of all such, whether they are formed of earthenware, glass, or metal, I think it better to pass to the consideration of silversmiths' ware, and thus continue a notice of hollow vessels, than pass to a consideration of glass windows, although they are formed of the material now under review. What we are specially considering at present is vessels of capacity, or hollow wares.

In the frontispiece to this volume the publishers of The Technical Educator have enabled me to place before the readers of my papers on the "Principles of Design" a few studies in original ornament.

Ornament of some kind is applied to almost every article that we see around us. The papers on our walls, the carpets on our floors, the hangings at our windows, the plates from which we eat, are all covered by patterns of some kind; yet it is rare, even now when ornamentation has become general, to find anything original in ornament; and if we do meet with something new in kind it is often feeble or timid-looking, if it does not altogether fail in impressing us with the idea that the producer was a man of knowledge. Let the reader be assured that if the designer is a man of knowledge, his ornamental compositions will never fail to reveal his learning; that if he is a man of power, his works will reveal his strength of character; if he is a man of refined feelings, that his designs will manifest his tenderness of perception. In like manner, that if a man is ignorant he cannot withhold from his patterns the manifestation of his ignorance. Did not the Egyptians express their power of character in their ornaments? did not the Greeks manifest their refinement in the forms which they drew? do we not even find an expression of religious feeling strongly, yea impressively, set forth by some art-works, as by the illuminated manuscripts of the early Middle Ages? and do we not every day see the impress of the ignorant upon certain wall-papers, carpets, and other things? It is a fact, and it is necessary that we fully acknowledge it, that the knowledge of the producer is manifested by his works; and that the ignorance of the ignorant is also manifested in his works.

If ornament is produced having new characters, it is often feeble, and is generally without grace; while power is the expression of manliness, and grace of refinement. Without claiming to have made a successful effort, I put forth, in the frontispiece to this volume, four of my studies in original ornament, all of which are to me more or less satisfactory as studies in composition. I have endeavoured to secure in each an amount of energy, vigour, or the power of life, yet at the same time to avoid coarseness, or any glaring want of refinement. I have sought to combine right lines, which are expressive of power, with such curved shapes as shall, with them, produce a pleasing contrast of form, and express a certain amount of grace. In the light ornament on the citrine ground (that at the lower left-hand corner of our plate) I have endeavoured especially to secure an expression of grace in combination with that amount of energy which avoids any expression of feebleness.

In the border ornament I have introduced the arch form, as it hints at a structural "setting out" which is pleasant; and I have endeavoured to cause the composition to appear as though it rested on the lower dotted band, as this gives a feeling of security. I do not say that it is necessary that this be so: all I assert is that in some cases it gives a feeling of satisfaction.

So far as I know, the colouring is also original. The colours employed are chiefly of a tertiary character, but small masses of primary or secondary colours are employed in order to impart "life" to the composition.

I do not set these studies before my readers with the idea of showing them what original ornament should be: I only set them forth as examples of new compositions, and must leave each to clothe his own thoughts with a befitting expression of his individual original ideas.

SEATS OF INDUSTRY.—XX.

LILLE.

BY WILLIAM WATT WEBSTER.

Among the trading and manufacturing towns of France, the ancient, prosperous, and progressive city of Lille holds a high place. Local tradition ascribes the origin of the town to Julius Cæsar, but there is no historical evidence whatever in support of this view. It is generally believed, however, that a château or castle existed at Lille during the last centuries of the Roman occupation of Belgic Gaul, and that round this stronghold the first beginnings of the town gathered. From its position in the midst of marshes, this castle was called Isla, and the town hence derived the name Lille or L'Isle, the island. No mention of Lille is to be found in the ancient chronicles previous to the time of Baudouin I., called Bras-de-fer, who in 863 caused several of his enemies to be hanged on the walls of the château. It was fortified by Baudouin IV., and captured by Henry III., Emperor of Germany, in 1054. In 1213 the city was retaken by Philippe Auguste, King of France, who reduced it to ashes. Towards the end of the thirteenth century it was again seized by Philippe le

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* Fig. 114 represents a decanter made for the Prince of Wales by Messrs. Pellatt and Co., and is in good taste.

Bel and again ceded to France, but it subsequently came into possession of the Counts of Flanders. In 1476 it passed to the house of Austria, and twenty years later it submitted along with the Netherlands to the domination of Spain, and was held by the Spaniards for about two centuries. Louis XIV. laid siege to it and captured it from the Spaniards in 1667; but during the wars of the Spanish succession, it was bombarded in 1708 by the allies, under the Duke of Marlborough and Prince Eugène, for 120 days, and compelled to capitulate. By the treaty of Utrecht in 1713, it was definitively reunited to France; but in 1792, the Austrians under Saxe Teschen fiercely bombarded it for six days, during which a great part of the town was burned; but after losing 20,000 men they were forced to retire.

Lille is situated on the canal connecting Scarpe and Lys, in a level, fertile district, 9 miles from the Belgian frontier, 62 miles south-east of Calais, and 124 miles north-north-east of Paris on the Northern Railway. It compares favourably with the generality of French towns in regard to the regularity, width, and breadth of its streets. The houses are, for the most part, built of brick; but are generally substantial and modern, though plain structures, and a portion of the town is constructed of stone, obtained from the neighbouring quarries. The quarter where the bulk of the manufacturing population resides, however, has a rather mean appearance. The town comprises about 300 streets and 32 squares. Few of the houses have more than two or three storeys, and the more recently erected have areas in front. Lille is supplied with water from the river Deule, that distributes itself into the canal on which it is built, several branches of which, navigable by small vessels, circulate through the city. In former times Lille was enclosed within a narrow circle of walls, forming an irregular oval, between four and five miles in circumference, exclusive of the fortifications and of the moat by which it was surrounded. By a decree passed in 1858, the suburbs of Wazemmes, Esquermes, Moulins-Lille, and Fives were annexed to the city, and the old fortifications on the south side were demolished and reconstructed beyond the territory incorporated. This new enclosure was completed a few years ago. The old fortifications, which were rebuilt at the beginning of the seventeenth century, were enlarged and rendered almost impregnable by Vauban, the celebrated military engineer. Next to Turin, the citadel of Lille is considered the strongest in Europe, and it is the masterpiece of Vauban. The new fortifications, which consist of brick and earth, are pierced by eleven ordinary gates, by three *portes à eau*, and by a special entrance for the railway. Several of the ancient gates of the city, of which there are six, deserve mention. The most remarkable is the *Porte de Paris*, which, though it formed part of the fortifications marked for removal, has been allowed to remain. It is a triumphal arch in the Doric style, erected in 1682, surmounted by a trophy, with a figure of Victory crowning the bust of Louis XIV. The *Porte de Gand* or *de la Madeleine*, and the *Porte de Roubaix* or *de Saint Maurice*, were constructed by the Spaniards in 1617 and 1622 respectively, and are built in brick of divers colours. A number of houses built in the Spanish style, between 1640 and 1680, are still to be seen in the vicinity of the theatre, in the Rue des Manneliers, at the end of the Rue de Paris, and in other quarters in the city. The citadel, which forms an irregular pentagon, is separated from the city by promenades, planted with trees, by the canal of La Moyenne-Deule, and by an immense esplanade. At the extremity of the promenades stands a statue of General Negrier, by Marcel Bra, a sculptor who contributed largely to the adornment of Lille. In the district surrounding Lille, there are extensive beet-root plantations, and the agricultural produce includes flax, tobacco, oil-seeds, etc. The immediate neighbourhood of the city is studded with bleaching grounds and oil mills.

Lille is one of the chief seats of the cotton and linen manufactures of France. A great variety of goods are produced, including calico, cotton cloths, cotton yarn, handkerchiefs, *indiennes*, hosiery, gloves, hats, blankets, lace, tulle, table linen, linen thread, fine woollen goods, beet-root sugar, leather, paper, mineral acids, etc. There is a Government tobacco manufactory in the city, and a saltpêtre refinery. It is estimated that Lille and its outskirts contain about 206,000 spindles for the spinning of flax and tow, distributed over eighty mills, employing a total of about 6,000 women. From 4,000 to 5,000 persons are engaged in the manufacture of sewing thread, which is carried on in some forty establishments. Only two workshops are devoted to the spinning of lace-thread. Woollen fabrics are made in some twenty mills. The number of spindles for spinning cotton exceeds 400,000, giving occupation to from 7,000 to 8,000 persons, and the produce represents an annual value of about 20,000,000 francs. Upwards of 110 establishments are employed in manufacturing common linen cloths, ribands, ticking, and damask; and 25 houses make canvas and packing cloth. In the making of smock-frocks or blouses about 4,000 women are employed. The manufacture of tulle and of lace has been steadily decreasing for a considerable time past in Lille, and threatens to leave the city altogether. About 1,200 persons find employment in the tobacco works, and the number of people who are engaged in the extraction and purification of oils, in dyeing, bleaching, sugar-making, brass-founding, machine-making, comb-making, rope-making, brick-making, and card-making is very large. There are in operation within the new boundaries of Lille about 260 steam-engines, besides about 50 in the vicinity, and 60 in the sugar-factories. In 1856 the population of Lille was returned at 67,775; in 1861 it was 131,827; and in "Joanne's Dictionnaire Géographique de la France," issued in 1869, it is stated at 154,749.

Lille possesses many public buildings and institutions, remarkable either in themselves or for their historical associations. The church of Notre Dame de la Treillé et Saint Pierre, begun in 1855, on the site *du Buc*, the cradle of Lille, is the largest and most beautiful ecclesiastical edifice in the city. It replaced the ancient collegiate church of St. Pierre, founded in 1066 by Baudouin of Lille, and destroyed during the Revolution. The church of St. Peter and St. Paul, at Wazemmes, is capable of containing 4,500 persons. There are many fine churches in Lille, adorned with pictures by Rubens, Van Vost, Van Dyck, Arnould de Vuez, and other famous painters, and with statues by Bra. The new Hôtel de Ville has since 1848 replaced the palace of Rihour, built by Jean Sans Peur in 1430 and inhabited by Charles V., from which it derived the name of Cour de l'Empereur. This palace was ceded by Philip IV. of Spain to the magistrates of Lille in 1660, and from that time till 1848 it was the Town Hall of the city. In the eighteenth century it was partially reconstructed after two fires. The façade of the Hôtel de Ville is in the style of the Renaissance, and is decorated with two symbolical statues by Bra, representing Lille artistic and Lille industrial. The Hall of Conclave (which contains a fine wainscot and six pictures by Arnould de Vuez) and the restored staircase are all that has been preserved of the ancient building. Two wings of the second storey of the pile are filled with a collection of paintings, embracing 149 pictures of the Italian, Flemish, and Dutch schools, including specimens of Raphael, Andrea del Sarto, Paul Veronese, Luca Giordano, Salvator Rosa, Rubens, Van Dyck, Jordaens, Sneyders, Van der Velde, etc., and about 300 paintings of the French school, including pictures by Valentin, Lebrun, Arnould de Vuez, and Wicar. A famous collection of drawings by Raphael, Michael Angelo, Poussin, Titian, Guido, Andrea del Sarto, Francia, Holbein, Callot, etc., bequeathed to the city by the painter J. B. Wicar; the public library, which comprises some 40,000 volumes and 515 MSS., many of them rare and valuable; the Museum of Natural History, and the Cabinet of Physical Objects, all find accommodation in apartments of the Hôtel de Ville. Besides, this edifice is the seat of the Tribunal of Commerce, the Council of Prud'hommes, the depôt for the *octrois*, the police office, and the residence of the chief civil and military authorities of the Department du Nord, of which Lille is the capital. The Bourse, which was begun in 1652, is a pile more remarkable for show than for taste. Built in brick and stone, it forms a square composed of separate houses, with a graceful steeple over the façade. The court is surrounded with arched arcades, supported by columns, and is adorned with a statue of Napoleon I., cast with the brass of cannons captured at Austerlitz. Among the principal remaining buildings are the Medical School and the Lyceum, and on the Grand Place stands a column commemorative of the siege of Lille in 1792, surmounted by a symbolical statue of the city by Bra. As a matter of course, Lille has suffered and will for some time feel the effects of the disaster that has befallen France, but she has not been specially unfortunate. In all probability she will soon recover her former prosperity.

MINING AND QUARRYING.—XV.

BY GEORGE GLADSTONE, F.C.S.

TIN.

SOURCE OF SUPPLY—NATURE OF ORE—STREAMING—MINING—PLAN OF MINE—MODE OF WORKING—TUTWORKERS—TRIBUTERS.

This metal is very limited in its geographical distribution; the principal commercial supplies come from Cornwall and Devonshire; from a district in the East Indies extending from the Malayan Peninsula to the island of Banca; and from the colony of Victoria.

On account of its comparative rarity, and the variety of useful purposes to which it is applied, tin usually commands a high price; at present (1871) upwards of £130 per ton, which is, however, considerably above the ordinary figure.

The only ore of tin which is worked to any extent is the Cassiterite or stannic oxide, SnO_2, but called by the miners "tin-stone." The sulphide of tin occurs in limited districts, but it generally contains arsenic and other ingredients which are troublesome to separate, while the process of smelting the oxide, as will be seen presently, is a comparatively easy one. The oxide is, however, obtained in two very different ways—by regular mining and by streaming. As the latter is the simpler and most probably the more ancient, we will refer to it first, though the stream-works are now becoming of minor importance through exhaustion.

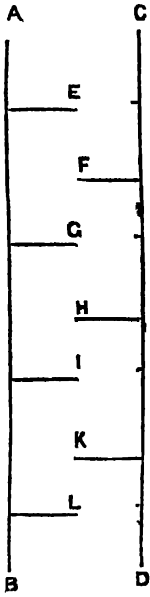


Fig. 6.

Stream tin is obtained just in the same way as gold-dust is ordinarily collected, by washing the detritus of the valleys in the district where the veins occur. The tin-stone being disseminated in small grains through the rock, becomes freed on the disintegration of the latter through the action of the weather wherever exposed to the surface; and as the ore has a very high specific gravity, varying from 5·6 to 6·9 according to its richness in metal, while the other ingredients of the granite, killas, and other rocks of the district have a specific gravity of 2·5 to 2·9 only, the tin remains behind while the lighter particles are washed away. The detrital gravels immediately overlying the rock are, therefore, generally stanniferous; and from time immemorial they have been washed to separate the ore. A great part of the surface of the southern half of Cornwall has been turned over from time to time in this search, and the few stream-works now existing are in localities which had previously been passed over on account of there being some practical difficulty in working them. Some of these have been carried by modern science under the beds of rivers, and even of inlets of the sea.

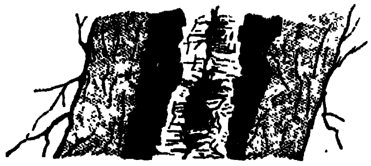


Fig. 1.

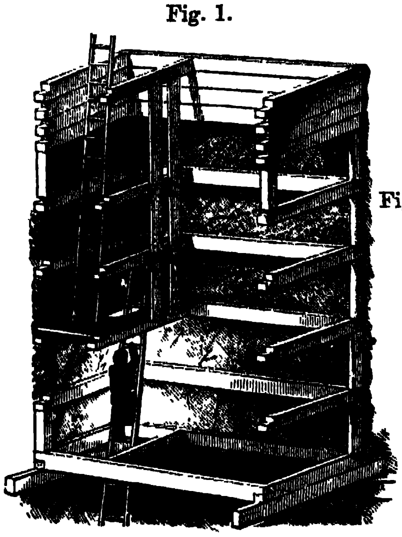


Fig. 5.

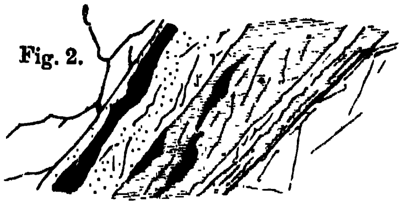


Fig. 2.

The tin-mines of Cornwall and Devonshire are generally found in those districts where the granite and other igneous rocks have forced their way up through the killas or Devonian formation, which is the prevalent rock in those counties. The granite occurs in large masses, of which there is one in Devonshire—the district of Dartmoor—and four in Cornwall; but besides these there are numerous porphyritic dykes, locally called "elvans," which ramify through all the country, but especially those parts which lie between the granitic centres; and these elvans are generally indicative of the presence of mineral veins. Taking them in the order of their importance, Truro, St. Austell, and Tavistock may be considered the centres of the mining operations. The veins which for the most part have an easterly and westerly course, often extend into the granite itself, but are generally richest about the junction of the two rocks.

In describing the mode of working a Cornish tin-mine, many of the details will equally apply to the working of copper and other ores which are disseminated in lodes or veins; so that it will be well to consider them fully now, and when treating of the other metals only to touch upon the specialities in the mining of each. Copper, indeed, is so generally prevalent in the same districts as tin, that there are few tin-mines in Cornwall in which copper ores are not also worked. Several mines which were originally opened for tinstone, became so poor in that mineral as the adventurers sunk deeper, that for a time they relied mainly on the produce of copper; some of these—Dolcoath, for instance—became in turn poorer for copper as they went still further, so as not to pay for working it, but have again become very rich in tin in depth, which is now the source of their great prosperity.

The main lode of an imaginary mine we will suppose to extend across the surface of the country in a crooked line, but having, as is usually the case, a general east and west direction, and that it dips down to an unknown depth in a southerly direction, as in Fig. 3 (see Vol. II., page 2), where A will be the north and B the south side of the diagram. Other smaller lodes may be near at hand, running somewhat parallel with this; and again another cutting through these at about right angles, which would be termed a "counter-lode." This last is probably charged with some other mineral, and throws the others out of their proper place, much in the same way as a fault disturbs the seams in a coal-mine.

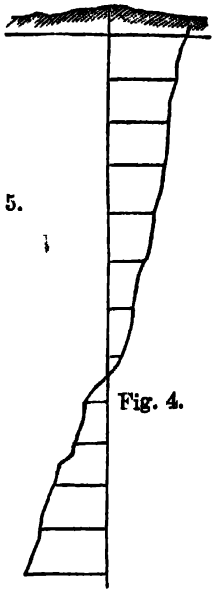


Fig. 4.

The lodes are not to be understood as being full of ore, for they contain usually a variety of substances, generally more or less parallel in their arrangement, as shown in Figs. 1 and 2. In tin lodes it is not uncommon to find copper on the hanging wall, and tin-stone at the corresponding part on the opposite side or foot wall, while the intermediate space may be occupied with mundic or sulphide of iron, arsenical pyrites, wolfram, and crystallised quartz. They are, moreover, very irregular in width and in contents; three feet may be taken as an estimate of their average thickness, but they range from an inch or two to several fathoms. The dip of the lode also varies very considerably from the perpendicular, often as much as 45°, though 20° may be taken as an average dip.

The first step in opening the mine is to sink a shaft to a certain depth, not much below the surface, that may be determined to be the best level for the adit. This, whenever possible, is fixed for such a level as will cut the surface in some hollow, and so enable the water to flow from it without pumping; and just sufficient inclination is given to it to cause the water to run. This is considered the starting point of the mine, and the depth of the various levels is measured from the adit, and not from the surface, which, of course, is often very uneven.

The adit (the main drain of a mine) is marked A in the accompanying diagram (Fig. 3), which represents a section of part of the workings on the counter-lode in the celebrated Dolcoath mine; and the upper levels are seen at distances of ten fathoms apart. The cross section of the main lode is shown at the side of the diagram, and marked D D. From the adit the shaft is sunk sometimes perpendicularly, and at other times following the dip of the lode; the latter is seldom done unless the dip is very slight, as a perpendicular shaft is the most economical for working. From the shaft, when perpendicular, the levels are driven to cut the lode, either to the right or left as the case may be, as shown in Fig. 4; and then, following the course of the lode, the ore is worked out between the levels, wherever, according to the judgment of the captain, it gives promise of the best result. Those portions which have been worked out at Dolcoath are left white in the sectional drawing, and will be seen to lie principally in the neighbourhood of the great elvan course. The elvans are indicated by the letter E. The granite and killas are distinguished by being shaded differently. The small shafts from one level to another are termed "winzes;" they are driven on the lode, partly for the sake of ventilation, and partly to afford an opportunity of seeing the character and richness of the lode for ore, which is necessary in setting the pitches, an operation to be presently described.

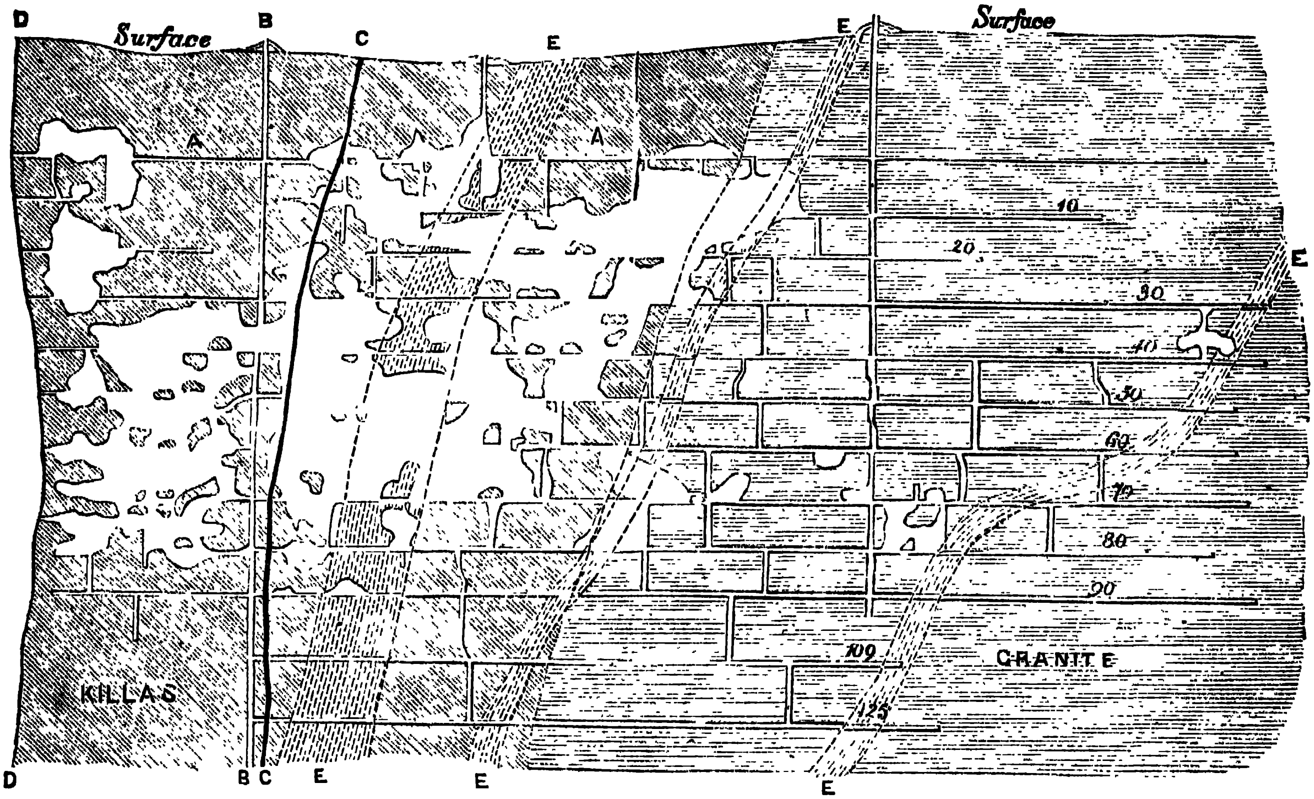


Fig. 3.—SECTION OF PART OF THE WORKINGS ON THE COUNTER-LODE OF DOLCOATH TIN MINE.

Tin-mines are often very wet, and it is therefore necessary so to lay out the plan of the workings that the water shall drain freely down to the pump, which is the bottom of the engine-shaft, so called because at the top of it is the pumping engine. Those used for drawing the ore to the surface are called whim-shafts. In large mines there are several of each, which are distinguished by different names, as Henriette's shaft, marked F B in Fig. 3, so named on account of its proximity to Henriette's lode marked C C. The rock through which the shafts are sunk is generally hard, and the progress made in sinking is often very slow; but a tin-mine has this advantage over a colliery, that the ore is reached near the surface, and returns may be made from the upper levels while still sinking to greater depths.

When a mine has been pretty largely developed, and it is desired to have a new shaft to communicate direct with some of the more distant workings, it is common to begin operations at both ends at once, and sometimes in the middle also, for the sake of saving time; but it requires no little nicety of calculation to secure that the several portions of the work shall meet properly.

The principle of exploring and working ore at the same time is constantly adopted in all mines; and it applies equally to opening them out laterally as well as in depth, the direction which the explorations take being generally guided by the character of the rock and the appearance of the lodes. Thus in the Dolcoath mine it will be seen that explorations have been pushed on the counter-lode far into the granite, though apparently with little success there. Had we before us a plan of the workings on the main lode, however, it would be found that some of the largest deposits of ore occur where it enters this rock.

A large quantity of timber is used underground, both as supports for the rock wherever weak, and in the shafts, as well as for tubbing wherever water occurs in quantity. Fig. 5 will illustrate the interior construction of the shaft, and the way in which miners ascend and descend. When a mine has reached a great depth the toiling up the ladders to the surface becomes a very serious matter, especially after having completed a day's work in so warm an atmosphere as that of a deep mine. It not only occupies unprofitably a great deal of time—three-quarters of an hour or more, perhaps, in making each journey—but demands great physical exertion also, both in descending and ascending. In the best-regulated mines a man-engine is therefore substituted for the ladders, by which the time occupied is reduced to about one-fourth, and very little exertion is required. These machines were first used in Germany, and their working may be best explained by reference to the accompanying diagram (Fig. 6). A B and C D are uprights which move in the shaft vertically by turns through a space of twelve feet, so that as one ascends the other descends; E, F, G, H, etc., are platforms fixed to the uprights, upon which the miners stand. The engine being set to work, the miner has only to step from E to F when the two have arrived at the same level, and then pause a moment until he finds himself on a level with G, when he steps back to the first side. At every step, therefore, he descends twelve feet, and ascends in like manner by merely reversing the order, H to G, G to F, etc.

The labour underground is performed by two classes of men, the tutworkers and tributers. The former are those who execute work by the piece, generally calculated by the fathom. By these the shafts are sunk, the adits driven, and all other excavations made in those parts of the mine which do not produce ores. The captain of the mine having decided on certain work to be done in various parts of the workings, lets out contracts for each job to a party of tutworkers at a price mutually agreed upon, which, of course, varies very greatly according to the nature of the work, hardness of the rock, etc. During the progress of their contract they receive pay on account, a sufficient margin being left to cover contingencies, and the balance is adjusted on the completion of each job.

The tributers work only at the extraction of ore. They form themselves into parties who agree to work a portion of a lode for a given time in the best manner they can, receiving as their remuneration a certain portion of the value of the ores raised, as may be agreed upon. The captain of the mine has marked out the several pitches which he proposes to set, and the tributers have inspected them, preparatory to the setting day. At the time appointed for that purpose they all meet at the office, the captain puts up the pitches to auction, the biddings proceed downwards, and the parties of tributers who agree to take the respective pitches at the lowest rates of tribute get the contracts, provided they are not above what the captain thinks they ought to be; when such is the case they are withdrawn for another occasion. The rate per £, of course, varies according to the apparent richness of the pitch and the price of the metal at the time, as it is calculated upon the money actually realised by the ores at the periodic sales, or upon an agreed price based upon the probable course of the market. The tributers buy their coals, candles, and gunpowder from the stores belonging to the mine, at fixed prices, and pay for hauling and raising the ore to the surface, as well as the wages of those who wash and dress the ores for sale. They also receive subsistence money during the progress of their contracts, the balances being paid as soon as the amount of them can be ascertained either from the actual sales, or by calculation based upon the agreed value. The tributers have still greater elements of uncertainty to contend against than the tutworkers, but then they are occasionally rewarded with a rich find; and in the long run they realise rather better wages than the latter.

PAPER AND CARDBOARD MAKING.—III.

BY GEORGE TINDALL.

PREPARATION OF THE PULP.

THE materials having been thoroughly digested by boiling in caustic liquor, until the various substances which require separation are either dissolved or thoroughly loosened from the fibrous portions, are now in a condition to be broken up and converted into pulp; but here some difference of treatment is required for the two classes of materials we have described; and, following the course we have taken in former papers, we will first describe the ordinary treatment of rags, and then point out the necessary variations in this treatment for crude vegetable fibres.

The first process to which rags are subjected after boiling is a rough breaking up in a machine termed a washing-engine, during which the remaining impurities, loosened by the strong course of boiling they have undergone, are washed out, and in which the process of bleaching, if the rags are intended for white papers, is usually performed.

The washing-engine is an oblong oval vessel, usually of iron, although wood lined with lead was formerly used. This vessel is divided down the centre with an iron partition or diaphragm, which serves for regulating the course of the material, the distance from the partition to the sides of the vessel being about the same in every part; the shaft of the roll extends across the engine, and in the most improved form rests in bearings placed on movable arms on each side, which can be simultaneously raised or lowered, and is driven by a belt on one side. The roll occupies the full width between the diaphragm and one side of the engine, and is usually about two feet in diameter, divided into partitions, in which steel bars are placed, fastened down by wedges, and firmly secured by an iron hoop inserted at the end of the roll. The floor of the engine is gradually raised to the front of the roll, and then rounded to its form, and in the bottom of this circular depression is placed the bottom plate, consisting of a number of steel bars similar to those in the roll, fixed firmly together, and fitted into a frame for convenience of removal. Each of these bars has a cutting edge, and when the roll is set in motion and revolving with great rapidity, the materials are drawn into the vortex thus formed, and passing between the roll and the bottom plate, are cut into minute fragments and thrown out violently on the other side of the roll. By this means the whole mass of materials in the engine becomes involved in the current, and is carried round and successively subjected to the action of the roll till sufficiently cut to pieces. Above the engine, and capable of being elevated and lowered by suitable machinery, is the drum-washer, as it is termed—a hollow cylinder fitted with buckets or suckers inside, and covered with strong coarse-meshed wire, and outside this with fine wire gauze. When the engine is charged with rags and filled up with water from a large supply-pipe brought to each engine, the roll is set going, and as the stuff is broken up the drum-washer is lowered down into the engine, and set in motion. The dirty water is taken up and discharged from orifices in the axis of the drum, from which it is carried away by means of a waste-pipe; at the same time a copious supply of clean water is poured into the engine; and this process is continued until the water flowing away is quite clear, and the rags are thoroughly cleaned and broken into very small pieces. A fine grating at the bottom of the engine allows of the escape of heavier matters, such as will not pass through the wire gauze of the drum-washer, into a square trough, which must be regularly cleaned out.

The process of bleaching is next performed, the materials being subjected to the action of chlorine until all the colouring matter they contain is destroyed, if for white papers, and as far as is necessary for other sorts. For this purpose the bleaching-powder of commerce or chloride of lime is employed. This is dissolved in a similar pan to that used for the conversion of soda-ash into caustic soda. The bleaching-powder is put into the pan, which is then filled with water, and after being agitated for some time, the clear liquor is run off into a cistern, which should be either of stone cemented, or should be lined with lead, and the connecting-pipes should also be of lead. Two or three liquors should be taken from the same portion of bleaching-powder, and the whole run into the tank, care being taken to use it regularly of the same strength to secure uniform results. A sufficient quantity of the clear liquor is now added to the materials in the engine, the action of the drum-washer being stopped, but that of the roll continued, so that the bleaching liquor is soon thoroughly mixed with the stuff as it passes along. The addition of a little sulphuric acid causes the chlorine to be liberated more readily, and thus assists the bleaching process. When ready, a plug is drawn at the bottom of the engine, and the bleached stuff, now called half-stuff, is carried through wood pipes and emptied into large stone cisterns having a floor of perforated flat tiles, similar to those used for the floor of malting-houses; here it is allowed to stand in the liquor for some time, and afterwards the spent liquor is drained away through pipes, and sometimes pumped into a cistern, to be used over again with other materials at the close of the washing process. Care should be exercised to use the chloride of lime in as fresh a state as possible, for the chlorine is continually being evolved where it is exposed, and the buckets used for carrying it should be made of gutta-percha or of sound hard wood, metal buckets being soon destroyed by the action of the liquor.

The process is very nearly the same for crude vegetable fibres, such as straw, esparto, and wood; but for these substances a poaching-engine, as it is termed, is used. This engine is similar in all respects to the washing-engine before described, but is usually much larger, and the roll, instead of being furnished with a large number of steel bars, has a smaller quantity of wood ones. The severe treatment necessary to destroy the silica and other impurities in these materials, softens the fibre so much that they are easily broken up, and only require the fibres drawing out, whilst the effect of the steel rolls is to cut up the materials subjected to its action, instead of bruising them, as is the case in the poaching-engine. The process of bleaching is similar to that described for rags, but it is usual to bleach these materials in a hot state, by injecting steam into the engine during the operation; this assists the bleaching, and enables that process to be carried further than is possible in the cold state, and with greater rapidity.

When the bleached material, or half-stuff, is thoroughly drained, it is thrown out of the cisterns, either into stacks or at once into boxes, and sent on to the beating-engines; but it is all the better for remaining some time—at least one whole day—in the cisterns, as the presence of free chlorine is very detrimental to the proper dyeing of the pulp.

The waste made in the manufacture of flax—a valuable material to the paper-maker, but one very full of "sheaf"—is, after being thoroughly drained in the cistern, subjected to another willowing process, called, to distinguish it from willowing unbleached materials, "white willowing." For this purpose it is put into a strong wrought-iron circular box, perforated with holes at the sides, and this is placed in a powerful hydraulic press, having a circular cast-iron block, nearly as large as the inside of the stuff box, fixed firmly to the top of the press; by this means the water contained in the half-stuff is effectually pressed out and passed through the perforated sides of the box, and the dried material passing through the willow, which revolves at an enormously high speed, is torn to small fragments, the fibres thoroughly loosened, and all foreign matters forcibly ejected in the current formed by the rapidly-revolving cone.

In the next stage, that of beating, the pulp is thoroughly prepared for the paper-machine, and here the greatest care must be exercised by the paper-maker, for upon the proper admixture and preparation of the materials in this process much of the character of the paper depends. The beating-engine is in all respects similar to the washing-engine first described, but is often larger, and the steel bars of the roll and those of the bottom plate must be regularly sharpened and kept in order, as here the stuff must be completely reduced to pulp, comminuted so fine indeed that no perceptible lumps or pieces of rag must be found in it, but every fibre drawn and separated from those with which it was before associated; here, also, the pulp must be dyed to the colour required, and, unless animal sized, that process must also be added. The engine is, in the first place, charged with the material selected, and with a copious supply of water, and the roll set in motion; here, too, a higher speed should be attained than for washing, one hundred and fifty revolutions per minute being required, and this must be kept up from three to six hours. First, a little hyposulphite of soda is added to destroy any free chlorine which may remain in the half-stuff after bleaching (this salt is usually called "antichlor" by paper-makers), and the drum-washer is also lowered, and used to wash out the resulting combination. The colouring matter is then added, ultramarine being the most commonly used for fine papers, whether white or blue; if for the former, rose-pink or some of the new magenta colours being added to give warmth of tone. Formerly the oxide of cobalt, or smalts, a very costly colour, was universally used for blue writing-papers, and for the finest hand-made papers this salt is still used; but the great improvements recently made in the manufacture of ultramarine has led to its more extensive use for the great majority of papers, and its effect is more pleasing to the eye, if not so durable as that of smalts. The agreeable yellow tone, latterly so much liked for book-printing, and even for some newspapers, is produced by the use of nitrate of iron instead of ultramarine, whilst various other salts are used, either alone or in combination, to produce the almost endless variety of colours in which paper is now made—a variety very largely increased during the past few years by the researches of chemists in the subject of coal-tar and other waste products, and the discovery of aniline, and with it of that beautiful series of colours which, for brilliancy and effect, far surpass the much-prized and, in some cases, lost colours of ancient times.

The earthy matters—such as clays and other mineral substances—are also introduced at this stage, to the great detriment of the strength of the paper, though sometimes to its advantage in appearance. In some of the lower classes of paper the percentage of mineral matters is very great, and even in good print-
china clay—as the fine white clay of Devonshire and Corn-
is called—is extensively used.

papers are now sized in the rag-engine—indeed, all the
r papers, as well as a large proportion of news and
gs, and a few writings, are sized in this way. For this
e rosin is boiled with somewhat less than half its weight of soda-ash, until it dissolves when beaten up in water; when cold the water is thrown off the top, and a stiff tenacious size is the result, which is stored for use, as it is much better after keeping at least a month. When used it is dissolved in boiling water, and the precaution is taken of passing it through a sieve, to keep back the impurities found in the rosin and soda-ash from which it is made. This precaution should also be taken with all the substances added during the beating of the pulp; the alum, antichlor, and also the clay, are best dissolved in water and strained through a wire sieve before they are used. Too much care cannot be taken to exclude foreign matters, especially if clean papers are being made.

Different materials vary very much in the amount of room they occupy in the beating-engine; esparto, for instance, is considerably more bulky for weight than rags, and after a little beating is considerably reduced in volume. Advantage is taken of this circumstance to introduce some other weighty substances, such as waste papers if they are used, to fill up the engines, and so increase the weight of pulp made in a given time, otherwise it is evident that more engines would be required for the manufacture of a given amount of paper from esparto than from rags; wood pulp also may be added after the volume of other materials is reduced by beating, and thus help as a filling.

When the engine is fully charged and the operation fairly commenced, the roll, which is started so as to run at some little distance from the bottom plate to allow the materials to pass easily, is by small degrees and at intervals gradually lowered, until before the operation is completed it runs in contact with the bottom plate. An ingenious piece of mechanism called a self-actor has recently been introduced, which relieves the engineer of the trouble of lowering the roll by performing that operation gradually and continuously during the process, and can be arranged to do so in a longer or shorter time, as may be necessary for different materials. This is a very useful adjunct, as it secures uniformity in beating, and guards against the carelessness of the man in charge, whose duties are then almost confined to seeing that the pulp travels regularly round the engine; as it is liable to stick in the neighbourhood of the diaphragm or at the bottom of the engine, and requires sending forward with a long flat rod, made something like an oar, so that every portion of the stuff may be subjected equally to the action of the roll.

It will not be unprofitable to compare this process of preparing pulp to that practised before the invention of the rag-engine and within the memory of some living paper-makers, when the rags, after macerating for many days in a close vessel until putrefaction set in, were beaten by means of stamping-rods shod with iron, much like the fulling-stocks not long ago used in the woollen cloth manufacture; these worked in strong oak or stone mortars, and the rags were literally almost "pounded to a jelly" in this rude apparatus. Forty pairs of these stamping-rods were required to work twenty-four hours in preparing pulp for one hundred weight of paper; now a single rag-engine will prepare pulp for three or four hundredweight of paper in four hours, and many paper-machines produce over twenty tons of paper weekly. But increased facilities for the manufacture of paper have been met by an increased demand, which is daily augmenting, and a single London daily newspaper now uses nearly one hundred tons of paper weekly, or the produce of three or four paper-machines, kept constantly running day and night, and the number of journals—daily, weekly, and monthly—is constantly increasing, so that apparently there is likely to be no lack of demand for any amount of paper that may be produced.

After the beating process has been carried on sufficiently far, which is ascertained by mixing a little of the pulp with a quantity of water, and carefully noting that no lumps are left, but that everything is reduced to minute fibres, which float about in the water, the pulp is conveyed by wooden pipes or shoots into large circular iron or wooden chests, preparatory to its final conversion into paper. Some care is required in sending down the pulp, especially if there is any sudden fall from the engines to the chests. If the plug is suddenly drawn, and the pulp allowed to rush rapidly down, the fibres sometimes mat together, forming little "knots," as they are called by the paper-maker, and these are sometimes so frequent as to give the paper quite a speckled appearance when looked through. To remedy this, the engine should be emptied gently, and plenty of water used to wash it down. This is a very common cause of the formation of "knots," though they will sometimes form in the stuff-chests, especially if the pulp is allowed to stand any considerable time before it is finally converted into paper.

TECHNICAL DRAWING.—LII.

GOTHIC STONEWORK.

NORMAN ORNAMENTS, WINDOWS, AND DOORWAYS.

Norman Ornaments.—The main feature in the Norman method of ornamentation consisted in the sculptured bands worked around the arches. These have been called *mouldings;* they are not, however, really such, but merely *decorations* of the mouldings. These ornaments are almost infinite in their variety, and all of a peculiar description. They appear in some instances to be additions carved on the originally unadorned surface of the masonry; but in most cases they were evidently worked on the block before construction. Amongst these bands, the earliest and most general is the chevron or zigzag (Fig. 458), which is frequently met with doubled, trebled, and quadrupled. The next most common on door-mouldings is the beak-head (Fig. 459), consisting of a hollow and a large round. In the hollow are placed heads of beasts or birds, whose tongues or beaks encircle the round. In the west door of Iffley Church, Oxfordshire, two whole orders are covered with these beak-heads, which extend down the entire length of the jamb down to the base moulding. We also find the alternate billet (Fig. 460), the double cone (Fig. 461), the star (Fig. 462), the square billet (Fig. 463), and the lozenge (Fig. 464). Amongst others we find the embattled, the dove-tailed, the interrupted arch, the open heart, the pointed arch, etc.

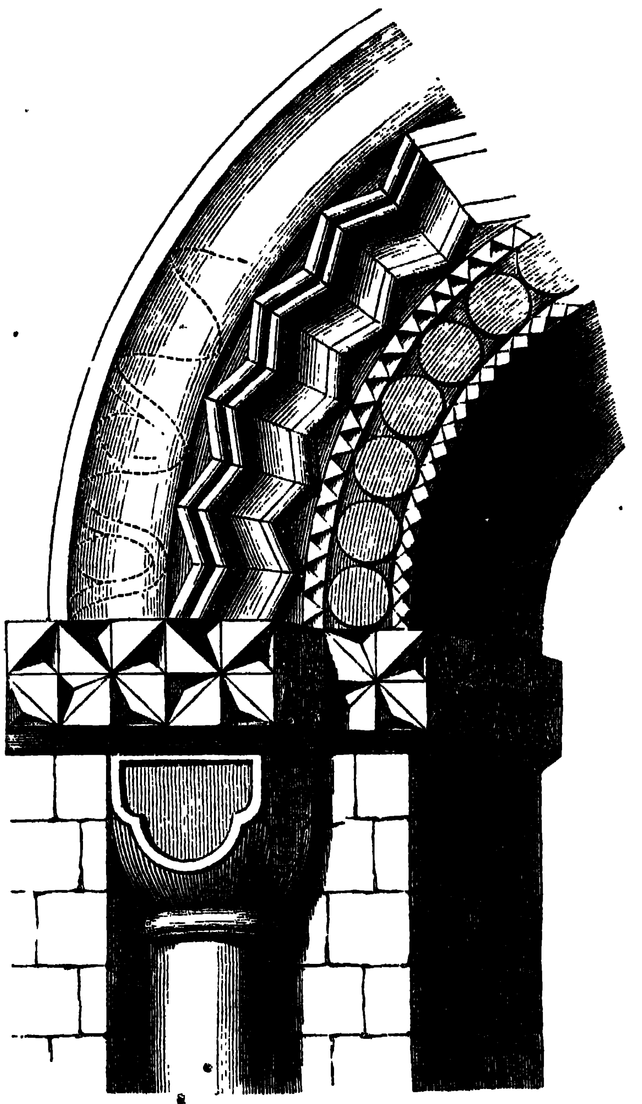


Fig. 467.

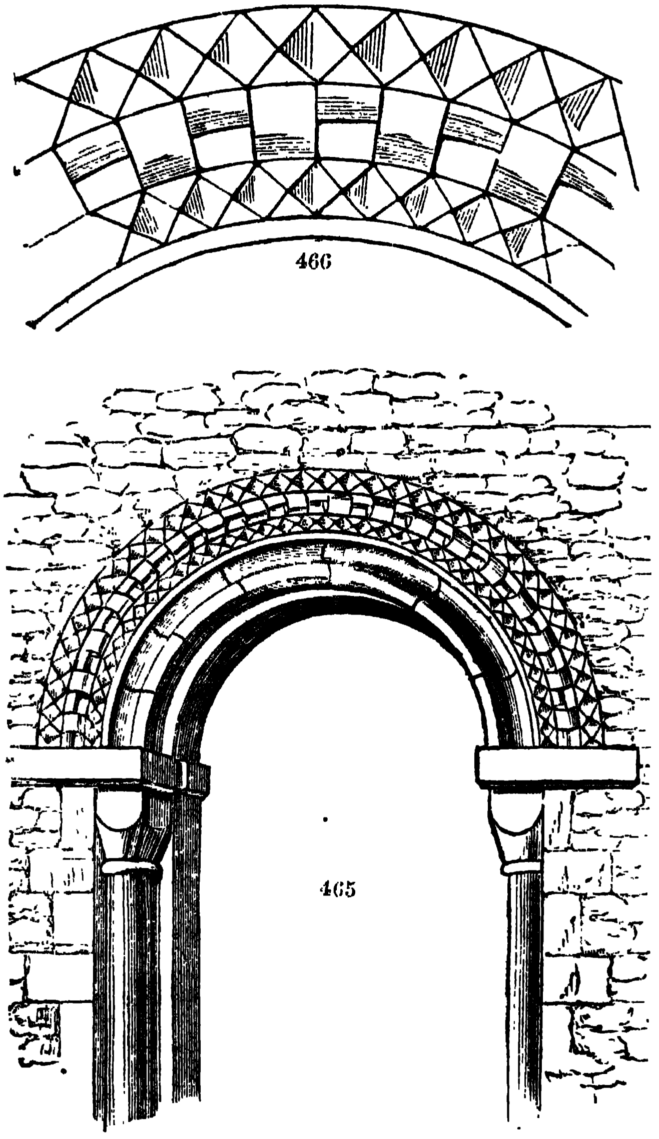
The immense number of these ornaments are here only indicated, our limits precluding further illustration of them.

The illustration (Fig. 465) is a view of the doorway of the porch of St. Mary's Church, Walmer, Kent, which, although small, is exceedingly characteristic of the style. The "outer order" is divided into three bands, which are ornamented, two with the "indented" or "trowel-point" band, and the one with billets alternately broad and narrow. The indented presents the appearance of a stuccoed wall which has been pressed with a trowel-point before setting, the point being pressed deeper into the mass than the broader portion of the blade. The second order consists of a hollow and roll moulding, and the third is left unadorned. Fig. 466 is a portion of the ornamental bands enlarged.

Fig. 467 gives a view of a portion of the chancel arch of the same church. In this example it will be noticed that the abacus—that is, the flat block which rests on the capitals—is continued from course to course, and round the jamb, being ornamented with a kind of diaper, formed of squares divided by lines parallel to the sides and by diagonals. The result is a star, which is worked very shallow, thus not destroying the flat character of the abacus. The capital is of the cushion character; but its height being rather greater than is usual, and the flat part being recessed in a kind of trefoil form, it has a rather elegant appearance, especially as the column is by far more slender than is common in Norman work. The outer ring of the arch has been covered with an ornamental band, which would seem to have been somewhat similar to the classic moulding called the "egg and dart." There is, however, only the barest trace of this remaining. Next follows the zigzag, and in the next order we again have three bands worked on the same ring—namely, a single indented pattern, which is merely another rendering of the zigzag, and which may perhaps have suggested the tooth ornament which forms so distinguishing a feature in the succeeding period. Next to this comes the "pellet" or stud, which consists of circular pellets placed next to each other, while the inner band is ornamented with the "trowel-point."

Norman Windows.—The windows at this period form but subordinate features in the buildings, and in earlier examples are little better than slits or narrow oblong apertures, often not exceeding a few inches in breadth, and finished with a plain semi-circular head. The glass was inserted close to the external wall, and the sides of the aperture were splayed towards the interior. The proportions of the Norman windows, as a rule, are the same as those of the doors, and very rarely exceed two squares in height, including the exterior ornaments. After a time the window-arches were enriched by the zigzag and other mouldings, and at a still later period an important improvement was made by inserting nook-shafts in the jambs, similar to those in doorways. A window of a still more advanced character is often found in the upper storeys of towers. It consists of two lights, with semi-circular heads, separated by a central shaft, and having a jamb shaft on each side. The two lights are enclosed under a larger semi-circular arch, the spandril of which, however, is rarely, if ever, pierced. Plain circular windows of small dimensions are sometimes seen in clerestories and other positions; and in churches of later date are occasionally found in gable walls larger windows of the same form, with small shafts radiating from the centre, connected at the circumference by semi-circular or trefoiled arches. There is a fine example at Barfreston, Kent.

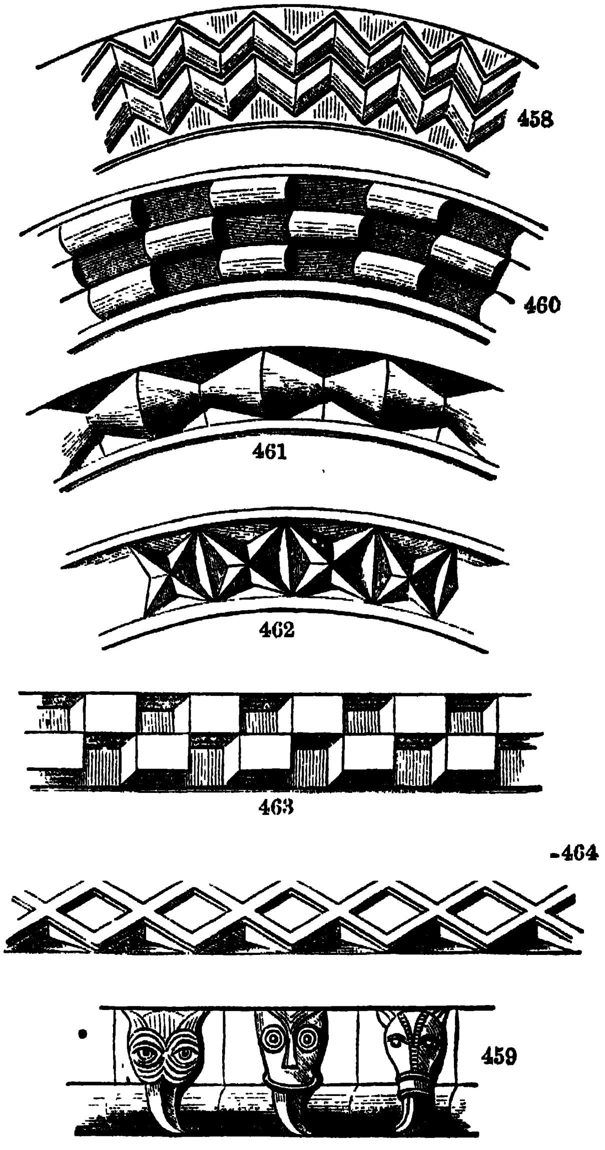
Norman Doorways.—These are to be found in great variety, from the most simple to the most elaborate. The most simple consists of merely a semi-circular-headed aperture, with a hood-mould springing from plain square-edged jambs. The arches spring directly from an impost resting on the jambs. More frequently, however, the doorways are recessed, having a nook-shaft in the angle, formed by a recession from the capital, from which an archivolt springs, so that the arch in this case presents two soffits and two faces, besides the hood-moulds. Sometimes we have a succession of such receding arches, with a nook-shaft in each recess, from which the arches spring alternately with the projecting square-edged jambs. The depth of the doorways is owing mainly to the great thickness of the walls; but in many cases, in addition to this, that portion of the wall in which the entrance is inserted is made to project forward beyond the general face, the projection being finished above with a plain horizontal capping, or with a highly pitched gable. With this additional thickness of walling we sometimes find as many as six or eight recessions, so that the aperture of the door occupies but a very small proportion of the space when compared with the entire surface taken up by the doorway, including the dressings. The soffits and faces of the arch, as well as those of the jambs, are sometimes left plain, but are more frequently sculptured with the ornamental bands just described, and to such an extent has this kind of decoration been sometimes carried that in many instances there is scarcely a single surface left uncovered with some form of ornamentation. Even the shafts of the pillars, as already mentioned, are sometimes decorated in a similar manner, but they are more often plain, with capitals of various degrees of enrichment. Occasionally an enriched band is carried across the shaft and jambs, as if to tie them together. The aperture often follows the form of the arch, having a semi-circular head, but is very frequently square-headed, having a semi-circular tympanum of masonry to fill up the space between the lintel of the door and the intrados of the arch. This is generally enriched with sculpture, sometimes in a sort of diaper pattern of reticulated or scallop work, but more frequently representing in low relief some portion of scriptural or traditional history. The west door of Rochester Cathedral is a splendid specimen of a doorway as here described. Not unfrequently the head of the aperture is in the form of a square-headed trefoil, and sometimes of the segment of a circle of a larger radius than the external arch.



Figs. 465, 466.—DOORWAY OF THE PORCH OF ST. MARY'S CHURCH, WALMER, WITH ENLARGED PORTION OF ARCH.

A great many examples of Norman doorways still remain even in churches which present no other features of this style, for it seems to have been a frequent practice with the architects of later periods to preserve this portion of an old church even when they rebuilt the entire structure in a later style. Many of these doorways are certainly very rich and beautiful, and their preservation does credit to the taste and judgment of succeeding ages.

Semi-Norman, or Transition from Norman to Early English.—To a period somewhat earlier than the middle of the twelfth century may be ascribed the first appearance of that change in the arch which in the thirteenth and the two following centuries became generally prevalent. The arch alone, however, is no real test, for "many pure Norman works," says Mr. Rickman, "have pointed arches. The square abacus, however, may be taken as the best mark. The pointed arch, in its incipient state, exhibited a change of form only, whilst the accessories and details remained the same as before; and although this change gradually led to the Early Pointed style in a pure state, with mouldings and features altogether distinct from those of the Norman, and to the general disuse, in the thirteenth century, of the semi-circular arch, it was for a while so intermixed as, from its first appearance to the close of the twelfth century, to constitute that state of transition called the semi-Norman."



Figs. 458-464.—VARIOUS FORMS OF MOULDINGS OF THE NORMAN PERIOD.

BUILDERS' QUANTITIES AND MEASUREMENTS.—IV.

BY E. WYNDHAM TARN, M.A.

EXAMPLE OF METHOD OF TAKING OUT QUANTITIES.

We shall now illustrate the foregoing rules by taking out the quantities of a rectangular building, 30 feet by 20 feet, three storeys high, the walls in the lowest storey being 2 bricks or 18 inches thick, in the next 1½ brick, and in the top 1 brick thick; the chimney-breasts projecting 9 inches, or 1 brick in each storey, and the foundations consisting of four courses of footings, having a set-off at each course, upon a bottom of concrete 3 feet 6 inches wide, and 15 inches thick; also a cross wall of cement concrete 9 inches thick upon the bottom storey, upon 6 inches of footings 18 inches wide, with brick-nogged partitions over it on the two upper storeys. The lowest floor is taken as having a tiled floor laid upon concrete. One front is faced with malms and tuck-pointed, the other being flat-joint pointed; flat malm cutter arches over all the windows and doors:—

CONCRETE.

2)	47 0 3 6 1 3	411 3	Concrete foundations, composed of 1 of lime to 6 of ballast.
2)	8 0 9 1 3	15 0	Add.
		426 3	
	17 0 26 3	446 3	6 inch concrete floor, as above.
	15 0 1 6	22 6	6 inch Portland cement concrete, 1 of cement to 8 of ballast.
	17 0 12 6	212 6	9 inch ditto, ditto, walling, including use of apparatus.
	7 0 3 0	21 0	Ddct.
		191 6	

BRICKWORK.

2)	47 0 3	23 6	4 bk. footings.
2)	47 0 3	23 6	3½ bk. ditto.
2)	47 0 3	23 6	3 bk. ditto.
2)	47 0 3	23 6	2½ bk. ditto.
2)	47 0 12 6	1175 0	2 bk. wall.
2)	7 6 3	3 9	1 bk. footings.
2)	7 2 3	3 7	Add.
2)	6 9 3	3 5	Add.
2)	6 5 3	3 3	Add.
2)	6 0 12 6	150 0	1 bk. wall.
		164 0	
2)	4 6 4 0	36 0	2 bk. ddct.
	7 0 3 3	22 9	½ bk. ddct.
3)	6 6 3 6	68 3	Ditto.
3)	6 9 4 3	86 1	Ditto.
		177 1	
	7 3 4 0	29 0	1½ bk. ddct.
3)	9 0 4 3	114 9	1 bk. ddct.
3)	6 9 4 3	86 1	Asphalte laid on wall.
2)	47 0 10 6	987 0	1½ bk. wall.
2)	6 0 10 6	126 0	1 bk. add.
2)	3 0 3 3	19 6	1½ bk. ddct.
4)	6 6 3 6	91 0	1½ bk. ddct.
4)	8 9 4 3	148 9	Ditto.
4)	6 9 4 3	114 9	Ditto.
		354 6	
	17 4 10 6	182 0	Bk. nogged partition.
	7 0 3 0	21 0	Ddct.
		161 0	
2)	3 6 1 6	10 6	½ bk. trimmer.
2)	47 0 9 3	869 6	1 bk. wall.
2)	6 0 9 3	111 0	Add.
		980 6	
2)	2 6 3 0	15 0	Ddct.
4)	6 0 3 6	84 0	½ bk. ddct.
4)	6 3 4 3	106 3	Ditto.
		199 3	

	17 9 9 3	164 2	Bk. nogged partition.
	6 6 3 0	19 6	Ddct.
		144 8	
2)	3 0 1 3	7 6	½ bk. trimmer.
2)	6 0 4 6	54 0	2 bk. wall to chy. stk.

No. 6. Flues cored.
„ 6. Moulded chimney-pots.
„ 1. Kitchen range setting.
„ 5. Register stoves ditto.
„ 12. Frames bedded and pointed.
„ 8. Air-bricks.

	3 0 3 0 2 9	24 9	C. bk. wk. in copper.
	1 2 1 6 1 0	1 9	Ddct. ash-hole.
		23 0	
	30 9 29 6	907 2	Malm facing.
	6 8 2 6	16 8	Ddct.
3)	6 2 2 9	50 11	Ddct.
2)	5 8 2 9	31 2	Ddct.
		98 9	
		808 5	
	4 0 1 2	4 8	Malm cutter arch.
	3 3 5	1 4	Add soffit.
11)	4 3 1 2	54 7	Add.
11)	3 6 5	16 1	Add.
		76 8	
	9 6 7 0	66 6	1 bk. arch to cellar.
2)	6 6 7 3	94 3	1 bk. wall to ditto.
	28 0 6	14 0	1½ bk. footings.
	14 6 3 3	47 2	1 bk. wall.
	5 6 6 6	35 9	Bk. on edge, paving in sand and grouted.
	30 9 29 6	907 2	Tuck pointing.

	6 8 2 6	16 8	Ddct.
3)	6 2 2 9	50 11	Ddct.
2)	5 8 2 9	31 2	Ddct.
		1005 11	
	69 3 29 6	2042 11	Flat jt. pointing.
4)	6 2 2 9	67 10	Ddct.
2)	5 8 2 9	31 2	Ddct.
2)	15 0 4 6	135 0	Add.
		2077 11	
4)	8 9 7	20 5	Cutting to splay.
12)	94 0	1128 0	Iron hooping as bond 1½ inch × $\frac{1}{16}$ inch.
6)	7 6	45 0	W. I. chimney bar, 2½ × ½ inch.
2)	15 6	31 0	Chamfer.
2)	16 0	32 0	Double tile creasing.
	65 0 4 6	292 6	1 bk. fence wall.
	65 0 6	32 6	1½ bk. footings.
	65 0	65 0	Extra to brick on edge coping in cement.
	60 0	60 0	6 inch glazed ware socket-pipe drains, jointed in cement.

No. 3. Junctions.
„ 2. Bends.
„ 1. Syphon trap.

2)	17 0 26 3	892 6	½-in. tile paving in cement.
3)	4 3 9	9 7	Add.
	3 0 9	2 3	Add.
	4 0 1 2	4 8	Add.
		909 0	
2)	4 6 1 6	13 6	Ddct.
		895 6	
	22 6	22 6	Cutting chase for R. W. P.

SHIP-BUILDING.—IV.

BY W. H. WHITE,
Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

COMPARATIVE FITNESS OF WOOD AND IRON FOR SHIP-BUILDING (*continued*).

We will next proceed to notice another point of interest having relation to the use of wood and iron—namely, the great contrast between the character of the *fastenings* employed. An iron ship is wholly fastened with iron rivets; the hull and its fastenings being formed of the same material. A wood ship, on the contrary, usually has iron or copper bolts for its principal fastenings, and these are obviously much harder than the wood, so that when straining forces act upon the hull the natural consequence to be looked for is a *yielding* of the softer material where it is pressed upon by its fastenings. This yielding may not be of perceptible amount in individual parts of the structure, but it is no less real, and in many instances leads to "working" in the hull. In short, as a result of the dissimilarity in character between the fastenings and the various parts of a wood ship, it is scarcely probable that the full strength of the material can ever be developed, no matter how well it may be disposed; because some amount of yielding, and consequently of "play," in the various parts is almost unavoidable. The same thing is not to be found in iron ships, for there the material is as hard as the fastenings, and the plating is no more likely to yield than the rivets are to "shear," when proper arrangements are made. As a result, it is reasonable to expect that a fuller development of the strength of the material will be obtained than is possible with wood ships.

It has been said before that wood ships usually show their weakness by hogging, and that under this condition their upper portions are subjected to tensile strains, while the lower portions are compressed. Against this compression it is easy to provide, as we shall see shortly; but for the reasons stated above it is not easy to make the longitudinal pieces and the decks efficient against severe tensile strains. Even in some of the modern wood ships of the navy, well built as they undoubtedly are, slight symptoms of weakness have been observed in the upper works; and in less carefully constructed vessels considerable changes of form are sometimes observed. It must not be overlooked that all such changes are disadvantageous, for they imply a yielding which must, in some measure, give scope for play and working in the various parts, and tend to reduce the vessel's durability as well as her strength. Recognising this fact, and desiring to prevent working in the upper parts of wood ships, some builders have for years past used iron beams for the upper decks, and fitted iron longitudinal ties upon the beams. This has proved to be a very great advantage, and has furnished further evidence of the superiority of iron to wood for ship-building purposes.

In this country wood is not easily obtainable of the sizes and forms required for ship-building, and has to be sought elsewhere; this was, as we have seen, a very serious drawback to the national industry a few years ago. When obtained, it is shaped and fashioned with considerable expense and difficulty, and it is moreover combined in a necessarily imperfect manner; besides which it is liable to many defects not easily discoverable, and often decays rapidly. On the other hand, iron is abundant with us; it can be procured readily of all the sizes and forms required, and shaped without difficulty; it admits of very superior connections and combinations; its defects are easily discovered if they exist; and its durability is greater than that of wood. No one is likely, after the experience of the last forty or fifty years, to question the greater durability of iron ships, and the only precaution needed is to prevent corrosion of the plating. Experience also has proved conclusively that iron ships may be made safer, as well as stronger, lighter, and more durable than wood ships, when they are built with proper water-tight subdivisions; and the cases which seem at first sight to go the other way, are really nothing more than examples of a faulty use of the material. Iron ships may, of course, be badly built as well as wood ships; but our point is, that when the capabilities of the two materials are each developed to the fullest extent, then iron is in all the above particulars superior to wood.

Doubts are frequently expressed as to the plating of iron ships proving sufficiently strong when they take the ground, especially on rocky bottoms, and the advocates of wood have strongly urged the superior capabilities of that material for bearing such rough usage. The fact cannot be disputed that under these exceptional circumstances the *thinness* of the bottom plating does tell against the iron ship, and that in many cases the bottoms of iron ships have been penetrated where the thick planking of a wood ship would not have been broken through, although it must have been damaged. But while admitting this, we would call attention to the fact that these circumstances are fortunately most exceptional, ships being primarily intended to keep afloat or to take the ground fairly, as any iron ship can do without danger; besides which it must be remembered that arrangements can be, and are, made in many vessels, by which the penetration of the outer plating does not admit water into the interior. The *Great Eastern*, for example, having a "double bottom" as it is termed, with two skins of iron placed two or three feet apart, kept afloat and proceeded on her voyage to New York, when a considerable portion of her outer plating had been torn away by striking on rocks off the American coast. It is true that in ordinary iron ships double bottoms are not fitted, builders and owners preferring to run the risk rather than to incur the expense; but even in these ships there are often transverse water-tight bulkheads in the hold, by means of which the spread of water entering the interior, in case of penetration, would be to some extent limited. And finally on this matter, it should not be forgotten that even when ashore and penetrated by rocks, iron ships have again and again proved themselves capable of enduring storms that would have beaten any wooden ship to pieces, and ultimately have been got off, repaired, and again made use of. The *Great Britain* furnishes a well-known example. She went ashore in Dundrum Bay, and lay on that wild coast for a whole winter; but having been got off and repaired, at a not extravagant cost, was again put into service, and is now running constantly between Liverpool and Australia. In face of evidence such as this, it is obviously improper to attach much importance to the argument against iron ships, based upon the comparatively easy penetrability of their bottoms.

The thinness of the bottom plating does, however, necessitate care on the part of the builder in order to prevent what are technically termed "buckling" and "panting"—*i.e.*, alterations of form due to the flexibility of unsupported parts. Ordinary precautions suffice to prevent any evil of this kind, and in a vessel with the frames, etc., well arranged, it need not be apprehended. It is, of course, most to be guarded against in vessels having very thin plating—for example, when steel is used instead of iron in order to save weight—but in no case need it be a matter of primary importance, or cause of great difficulty in construction. It is a matter of common observation that a thin flexible plate of iron, incapable of bearing its own weight without bending between the points where it is supported, can be made capable of bearing heavy loads by securing to it another thin plate having its depth at right angles to that of the first plate; in fact, the combination of the two forms a strong T-shaped girder. And on this principle, the plating of an iron or steel ship, although very flexible when unsupported, can be readily stiffened by a very small expenditure of material. It would be hard, if not impossible, to find a parallel case in the construction of a wood ship.

Up to the present time the capabilities of iron are far from being developed fully in ship construction, and in the majority of iron ships methods are still retained in use which were first copied from wood ships, notwithstanding that numerous examples of better methods may be found. To name one example only, the frames of iron ships will sufficiently illustrate this statement. Like those of wood ships, the frames of ordinary iron vessels were placed transversely at first, and the practice still continues. With wood, the arrangement was probably the best possible; but with iron, and especially with a skin formed of plates efficiently connected together, the case is widely different; and Mr. Scott Russell, in the *Great Eastern* and other vessels, initiated a great improvement by placing the main frames longitudinally instead of transversely, so that they could assist the skin and decks in bearing longitudinal bending strains. It cannot be denied that habit, formed by years of practice, renders it easier to build on the old plan; nor is it meant that the old plan does not answer fairly; but rather that there still remains considerable *possible* improvement to iron ships, while it is difficult to see in what particulars considerable improvements can be made upon the existing methods of constructing wood ships. Moreover, in the immediate future it may be anticipated that the use of *steel* for ship-building will become common, and then still greater advantages than can be gained with iron may be looked for, seeing that the stronger material will be used in thinner plates and bars, and will consequently have to be combined according to what are now considered the best methods of iron ship-building, if not according to still more improved methods. Thus far the manufacture of steel does not appear to have reached that stage which enables the material produced to be regarded as in all cases thoroughly trustworthy; but this is not likely to remain so long after the demand for steel ships becomes great. Without sacrificing any of the advantages of iron, the ships built of steel will be very much lighter without being weaker, and the gap between them and wood ships will be still more remarkable than that between iron and wood ships.

The only drawback to the use of iron or steel—foulness of the bottoms of ships—will, we trust, be removed by means of some discovery ere long. It is a serious matter, no doubt; the source of much inconvenience and expense; but in spite of it iron continues to make way, and to displace wood, both in this country and abroad. Whenever vessels of extreme dimensions are required, or wherever unusual strength is needed, then or there does the ship-builder now turn to iron, and before long will turn to steel. Larger and longer ships have already been built than was thought possible a few years ago, and their use is found beneficial in every way: the men who would attempt to predict what dimensions may ultimately be reached would indeed be bold. The *Great Eastern* as yet stands quite alone, far exceeding in size any other ship; and in her construction is found sufficient evidence of the fact that in ordinary ships the capabilities of the material are far from being exhausted. Commercial considerations, not the necessities of structural strength, will in future fix the dimensions of the ships built; but if wood had continued to be the sole material in use, such a freedom of choice would not have been possible.

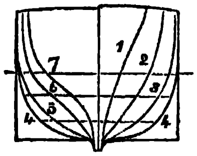


Fig. 13.

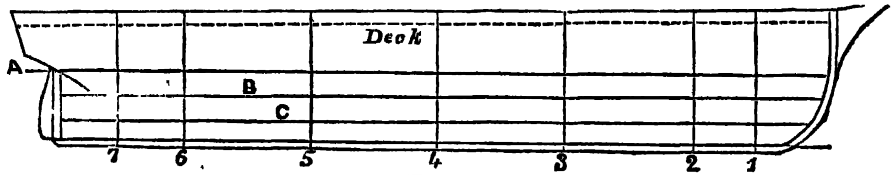


Fig. 11.

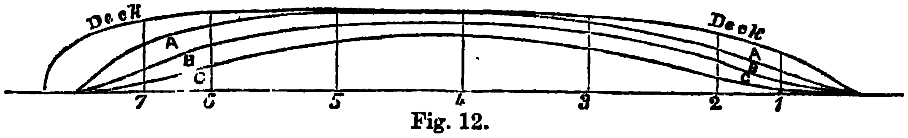


Fig. 12.

SHIP-DRAWINGS AND SPECIFICATIONS.

The design of the naval architect, when it passes into the hands of the ship-builder, is embodied in a specification and certain drawings. From the specification can be obtained particulars of the principal structural arrangements, including the details of the sizes, or scantlings, of the various parts; from the drawings may be gathered a complete knowledge of the form and dimensions of the vessel to be built, as well as of the arrangements of decks, platforms, etc., and the general requirements for stowage and accommodation. Even when thus supplied the builder has much left in his hands, and needs to exercise care in order to secure good combinations of the various parts.

This part of the work of private ship-builders is practically regulated by rules laid down by such bodies as Lloyd's Committee, and the Committee of Liverpool Underwriters, by whom registers of shipping are published, in which vessels are classed according to their character and condition, these being ascertained by surveyors acting under the direction of the committees. Lloyd's Committee is the older and better known of the two; and the phrase "A 1 at Lloyd's" has almost passed into a proverb. Underwriters are considerably guided in fixing their rates of insurance upon ships by their classification in those registers, and consequently ship-owners find it to their interest to have vessels built in accordance with the rules of the committees, in order to ensure them a high classification. It would be beside our purpose to discuss these rules here; it must suffice to state that they really furnish detailed specifications, ready made as it were, for various sizes and classes of ships; wood, iron, and composite ships being all provided for by Lloyd's Rules. The beneficial effect of these rules upon the practice of private ship-builders cannot be doubted, although some of their stipulations have caused considerable discussion, and have from time to time been modified. They represent, in fact, a great mass of information gained by experience, as well as no small amount of mechanical skill, and a fair appreciation of the science of ship-construction. With the rules before him, the builder is almost inexcusable who commits any serious mistake, and he is relieved from almost all consideration of what scantlings will be required in his ship.

In the Royal Navy the case is different, because the ships are not built to be classed, and because they are, as a rule, larger than merchant vessels, besides being designed for an entirely different service. As a consequence there are to be found many differences between the methods of construction adopted in the Royal and private dockyards, both as regards wood and iron ships, but especially the latter. It is necessary, therefore, to have a more or less detailed specification for each war-ship built, or rather for each class; and in framing such specifications regard is, of course, had to past experience as well as to present requirements. Although private builders do not conform to the practice of the Government service, they are by no means slow to admit the general superiority, in a structural sense, of the ships of the navy; but, on the other hand, they justly lay stress on the commercial aspect of the question, and prefer the cheaper vessel that answers their purpose fairly, to the better-built but more expensive vessel that they might produce, if structural considerations only had weight. This argument may, however, be pushed too far, and lead to false economy.

The drawings supplied to the builder claim but a brief notice. The principal one of the set is usually termed the "construction drawing" or "sheer draught;" and besides it there are a "midship section," "profile of inboard works," "deck plans," and "plan of hold." The sheer draught and midship section would be used at the outset by the builder, and the other drawings would come into use at further stages of the work. We will glance at them in the order named above.

The construction drawing usually consists of three plans, showing projections of various sections of the surface of the ship, and her decks, etc., upon three planes mutually at right angles—corresponding, we may say, to the "front" and "side elevations," and the "ground plan" of a house-drawing. These three plans are named respectively the "sheer," "half-breadth," and "body" plans, and are usually arranged as in Figs. 11, 12, 13. If we imagine a ship to be cut down the middle by a longitudinal plane, and the various sections of her surface, etc., to be projected upon it, we shall obtain a correct idea of the sheer plan, which gives consequently a profile view of the ship, showing her upper and lower boundaries, the stem and stern, the positions of the decks, etc. From the sheer plan, therefore, the position of any point in the ship's surface can be determined so far as *length* and *height* are concerned, as will be readily seen by referring to the outline sketch in Fig. 11.

The half-breadth plan contains the projections, upon a horizontal plane, of the various lines shown in the sheer plan; showing, for instance, the boundaries of decks, and the forms of the "water-lines"—*i.e.*, sections of the ship's surface—by horizontal planes. From this plan the position of a point can therefore be fixed, so far as *length* and *breadth* are concerned. Only one-half of the ship is shown in this plan (see Fig. 12), as the two sides are, of course, exactly alike.

The body plan is the supplement of the other two; its plane is at right angles to both of them, and from it measurements in *height* and *breadth* can be determined. It usually consists of two parts, having a common middle line (as shown in Fig. 13), exhibiting respectively the forms of transverse vertical sections of the ship at "stations" before and abaft the midship section.

The part of the ship before the midship section is termed the "fore-body," and transverse sections belonging to it are drawn in the body plan to the *right* of the middle line. The remaining part, or "after body," has the sections belonging to it drawn to the *left* of the middle line in the body plan. These sections, it should be stated, are situated at the places where the transverse frames are placed in the ship, and the "stations" of these frames are represented by straight lines in the sheer and half-breadth plans.

The body and sheer plans are, it will be noticed, placed on the same base-line—an arrangement that is of assistance in transferring heights from one to the other. The stations 1, 2, 3 in all three plans correspond, and the transverse forms of the ship at them are shown in the body plan. The lines marked A, B, and C are what have been termed "water-lines," the true forms of which are shown in the half-breadth plan. In an actual construction draught these water-lines would, of course, be more numerous than in our sketch, and the sections in the body would also be more numerous, representing, in fact, stations only 6 or 8 feet apart. Our object being simply to illustrate the great features of the drawing, we have shown only a few examples of each. Station 4 in Figs. 11, 12 is what would be termed the midship section, and it appears in both halves of the body plan. If the vessel has more decks than one, they are shown in the sheer plan, but not usually in either of the other plans. On the sheer plan it is also customary to indicate the positions of the masts, openings in the sides of the ship, bulkheads in the hold, etc.; constituting it, as we said, an outline profile view of the ship, but omitting details that are shown on the "profile of inboard works" drawing.

By making use of all three plans it is possible to determine the true form of any section of the ship; but to do this requires a good knowledge of geometry, the twisted and curved surfaces of ships being much more difficult to deal with than the plane surfaces furnishing the ordinary problems of civil architecture and building construction. Moreover, it is obvious that for the ship-builder's purposes it is far more important to be able to determine the forms of sections of the ship when stripped of her skin, than when clothed with it; for he has first of all to fashion and fix the frames, and then to work the skin upon them. Consequently, the construction draught used by the builder is made to represent the ship's form at the *inner* surface of her skin; and although the difference between this and that at the outer surface is not great in an iron ship, it is considerable in the thicker-skinned wood or composite ship.

The drawings supplied by the designer of the ship are on a small scale, usually $\frac{1}{48}$ of the full size (or $\frac{1}{4}$-inch to a foot). For the shipbuilder's use some parts of them require to be enlarged to the full size, and this is done generally on the "mould-loft floor," the smooth plane surface of which is prepared for the purpose. The object of this process—"laying down," as it is sometimes called—is obvious—viz., to provide the means of making patterns or "moulds" of the frames and other parts of the structure. It would naturally be expected, too, that in the process of enlargement discrepancies between the three plans would become apparent which could not be detected in the small-scale drawings, and to eliminate these is a very simple matter, the technical name for which is "fairing the body." When all three plans are found to agree, the body is said to be "faired," and the process of "laying-off" has to be begun; in fact, this term is often used as including also what we have termed "laying-down." When faired, the sections in the body-plan actually represent the curves to which the frames, if transverse, must be fashioned, and at once the work of mould-making can be begun, or other means adopted for the same purpose.

The process of laying-off a ship, particularly if she be wood or composite, presents considerable difficulty, and is undertaken by a special class—the draughtsmen, who are usually practical men of superior ability, and have very responsible duties to perform. The preparation of the moulds for the various parts of a ship is in itself no light task; and in addition the draughtsman has to prepare dispositions and arrangements, under the direction of the shipbuilder, the mere enumeration of which would be tedious. It is impossible for us to give even an outline of the work done in the mould-loft; for laying-off is a subject requiring separate treatment, including as it does all the "practical geometry" of ship-building. We must therefore pass on, with the remark that its study cannot fail to benefit, both as a geometrical exercise, and as an illustration of the principles that govern the conversion of the materials used in ship-building.

Little need be said respecting the other drawings used by the ship-builder. The "midship section" gives a view of the framing of the vessel amidships, and this has a great influence on the framing throughout the length. This drawing is, in fact, almost inseparable from the construction draught, and comes into use as soon as the work on the mould-loft floor is begun. The usual practice is to lay down the midship section curve on the floor from it, before the body is faired; but it is more frequently required afterwards.

The deck plans, plan of hold, and profile of inboard works are needed to guide the ship-builder in spacing the beams and bulkheads, providing the necessary hatchways, fitting special strengthenings where required, and in many other ways while the work of building is progressing; but they are most in requisition when the "fittings" of the vessel are being proceeded with. None of these drawings, it should be remarked, are transferred to the mould-loft floor, or enlarged; they are sufficiently accurate on the small scale for all practical purposes, and measurements are taken direct from them. In building steam-ships it is also common to have drawings of the engines and boilers, showing details of the machinery, etc., and of the positions of the "bearers" that have to bear and distribute the weight.

While carrying out his work, the builder has need of many other drawings, showing details of separate parts of the structure, and prepares these for himself. For example, it is usual to prepare a detailed drawing of the framing of wood ships, to guide the men engaged in trimming the timbers; also to have what is termed an "expansion" drawing, showing the lengths and breadths of the planks or plates forming the skin, and to have similar sketches for the deck planking, besides many minor drawings. These serve a double purpose, enabling the builder to secure good combinations, and also enabling him to procure the necessary materials—for instance, from the mould-loft floor and the expansion drawings he can order all the plates for the bottom of an iron ship very nearly to their correct shapes and sizes, avoiding unnecessary waste and expense; or in case of a wood ship, he can foresee at an early stage of the work what timber will be required for conversion into bottom planking. This principle applies all through the work, the satisfactory progress of which depends very greatly upon the foresight of the builder in providing the necessary materials in good time.

It may be interesting to remark, in passing, the great differences existing between the practice of the wood and the iron ship-builder in providing their materials. The former has to procure much of his timber in the rough, and to expend considerable sums on its conversion to the forms and dimensions he requires; whereas the iron can be procured direct from the manufacturer, of nearly such forms and sizes as the ship-builder requires—no mean advantage. Many builders supplement the drawings by a model, on a small scale, of the ship to be built, and on the surface of the model draw lines showing the stations of the frames, the disposition of the outside plating or planking, the arrangements of the longitudinal pieces adjacent to the skin, etc. The practice is a very good one, and in many cases where it is followed expansion drawings are not made. In fact, such drawings are never more than approximately correct, exactitude being made impossible by the fact that the surface of a ship cannot be spread out on a plane surface—or "developed"—without cutting it into pieces; and on this account it is by no means unusual to use the model instead, as that gives a true idea of the form of the various pieces of the skin. In either case it is a wise precaution not to depend solely upon measurements obtained from the small-scale representation of the ship, but rather to measure from the full-size sections on the mould-loft floor, whenever that can be done, as it may be in the case of the frames and beams as well as that of the skin.

OPTICAL INSTRUMENTS.—XV.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

Hydrogen Generating Apparatus.—In the usual way, where house gas is attainable, it is employed to save the trouble of making hydrogen, but undoubtedly the latter (H) produces a brighter and also a more economical light than carburetted hydrogen (C_2H) when these are forced upon a lime-ball in combination with oxygen, as the combining volume of H with O is as 2 to 1, while that of C_2H with O is as 2 to 2, or equal volumes; consequently, when house gas is used more oxygen is consumed in a given time. In localities where there is a good pressure from the main, a very decent light may be obtained by connecting the jet directly with a tap soldered into the pipes that supply a house; but where the pressure is only moderate (as in some country towns), or the best light attainable is desired, then the house gas must be "run off" into a gas-bag, gasometer, or other receptacle that will allow of the gas being delivered at any required pressure.

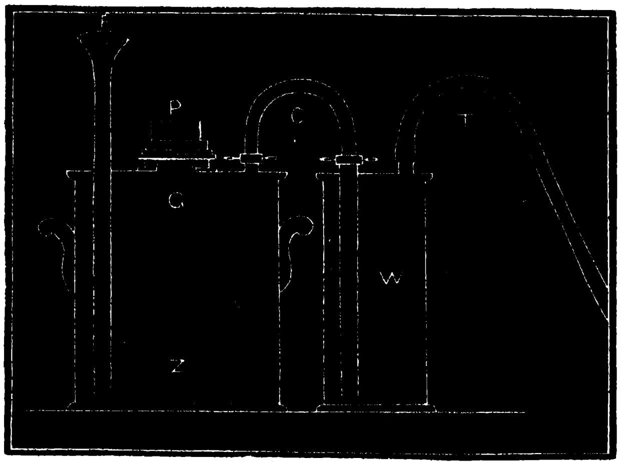


Fig. 50.

Hydrogen is made by acting upon zinc with water acidulated with sulphuric acid, in which operation sulphate of zinc is formed and hydrogen is set free. The process may be conducted in a glass Woulfe's bottle, or preferably, in a generator, as shown in section in Fig. 50. This consists of a round reservoir, G, made of stout sheet lead, wherein all the seams are carefully welded. The tap is fitted with a wide gun-metal plug and washer, P, to allow of granulated zinc, or, better still, *clean* zinc cuttings, Z, being introduced and then closed up. This vessel is then filled about two-thirds full with a mixture of one part of sulphuric acid to seven parts of water, and on the action subsiding, more acid can be added through the funnel, F. The hydrogen as generated passes over by a leaden connecting-tube, C, to the dip-tube of a leaden wash-bottle, W, and after being purified by passing through the water, is carried off to the gas-bag or other receptacle by an india-rubber tube, T. We may dispense with a separate receptacle for the hydrogen gas, and deliver it direct from a leaden self-acting generator, constructed on the principle of Doebereiner's lamp. This generator is divided into two compartments connected by a tube, as shown in section in Fig. 51. The lower part is filled with sulphuric acid and water till it runs out at the stop-cock; this tap is then closed, and the acid mixture acting upon a cylinder of zinc, Z, that is supported on the outside of the connecting-tube, causes hydrogen to be generated; but the gas having no vent from the lower chamber, forces the liquid up the tube into the upper compartment. As soon as the acidulated water is driven below the zinc, the production of gas, of course, ceases. On the tap being turned, the gas is driven out with considerable force, through the pressure of the liquid descending from the upper chamber—which on coming in contact with the zinc again causes hydrogen to be given off—so that a continuous supply of gas is maintained as fast as it can be consumed by the jet, and with the necessary amount of pressure. As the gas should be washed before reaching the jet, it is better to pass it through my "interceptor" (to be afterwards described), as this not only serves as a wash-bottle, but also acts as a safety arrangement, should the hydrogen by any accident become contaminated with air, which, it must be remembered, then becomes an explosive mixture. Whatever form of hydrogen-generating apparatus is employed, a certain portion of gas should be allowed to pass away before a light is applied to the jet, or any part of the delivery-tubes, in order to provide against the accidental contamination which I have already referred to.

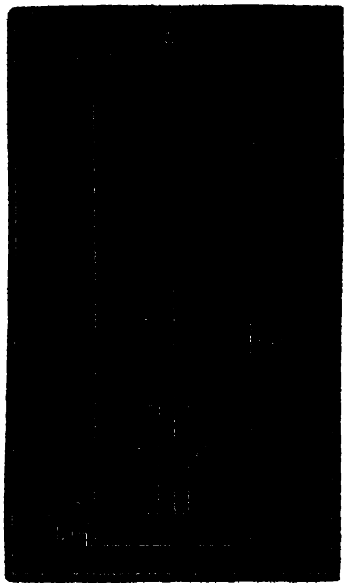


Fig. 51.

As the generator above described must be made in lead, it is, though a very convenient, a costly arrangement. One similar in principle may be cheaply made out of two large pickle-bottles, fitted with good bungs, and glass tubes arranged wash-bottle fashion, with connecting-tubes of india-rubber, as shown in Fig. 52. The zinc scraps, Z, are placed in the lower bottle, G, the sulphuric acid and water in the upper bottle, R, which is supported on a shelf in the box that contains the apparatus, and at such a height as will give the required amount of pressure. To commence operations, the acidulated water is driven into the lower vessel by blowing down the mouth-piece, M, till the liquid reaches the bung that closes G, for the purpose of driving out all atmospheric air; the tube, C, that connects the generator with the "interceptor" washing-bottle, is then closed with a stop-cock or chemical "pinch-cock." As in the former arrangement, when the gas begins to be generated, the liquid is driven up the tube, P, which provides, by its syphon action and length of tube, the required pressure. On opening the pinch or stop cock, the hydrogen is washed by passing through the water of the interceptor, I, and is carried off to the jet by the delivery-tube, D. Should an explosive mixture be found in the tubes, through inattention to equalisation of pressure, etc., in the oxygen part of the apparatus, the interceptor would completely isolate the generator, G, and the explosion would then be confined to the gas contained in the tubes.

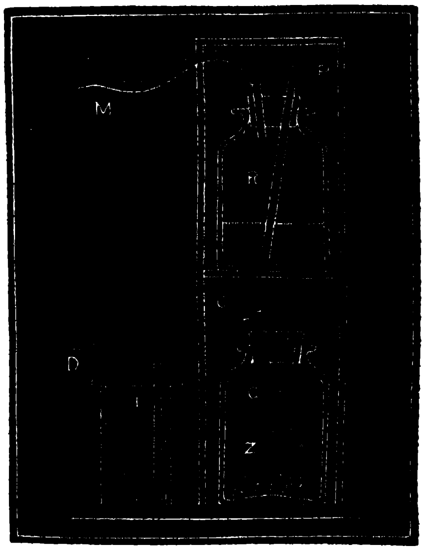


Fig. 52.

Gas-bags.—The receptacles ordinarily employed for storing oxygen and hydrogen gas for the lime-light apparatus are wedge-shaped bags made of waterproof cloth. Two qualities of this material are used, "thin" and "thick:" the former is made with jeanet, and is suited for the oxy-calcium jets, when low pressure is used; the latter is made with twill, and is requisite when the mixed gases are used under high pressure, or when the bags are likely to be in frequent use and extra strength of material is desirable. The thin bags are cream-coloured, while the twill is usually black, but it may also be had of a light colour, and when both gases are used it is advisable to have one bag black and the other white, and to keep each of them for the same gas, independently of marking each bag H and O. It is a good plan to have the taps of the lime-light jets differently lacquered; thus the oxygen tap of the oxy-calcium jet should be bright lacquered, as it will correspond with the light colour of the thin oxygen bag. In the mixed gas jets the bright tap should again correspond with the light-coloured though stout-made bag used for the oxygen gas, but the other taps should be dark bronzed to correspond with the black bag kept constantly for the hydrogen gas. By thus methodising the arrangements, there is less chance of the gases being accidentally mixed in the bags, as would arise if they were indiscriminately used, first for one gas and then for the other. The stop-cocks fitted to the bags should have a large bore to give free passage to the gas. The taps are best made of lever-form, and so fitted in the plug that when closed the lever stands lengthways with, and not at right angles to, the stop-cock, so that not only may one know by the feel, when in the dark, whether the plug is full on or off, but it also enables us better to secure the gas when travelling by binding a string round the lever-arm and the stop-cock. The nozzle of the cock should be slightly conical, ribbed, and sufficiently long to secure a good fitting for the india-rubber tubes that are sprung on it. Before a bag is filled, it should be laid flat on the floor or table, folded smooth, the stop-cock opened, rolled up tightly, so as to drive out all air, and then the tap should be closed. It may then be connected by tubing with the generating apparatus, and when the gas is coming over properly, the cock may be opened and the bag filled, till it is as tight as a drum, when the cock must be closed, and the tube disconnected from the wash-bottle.

Fig. 54.

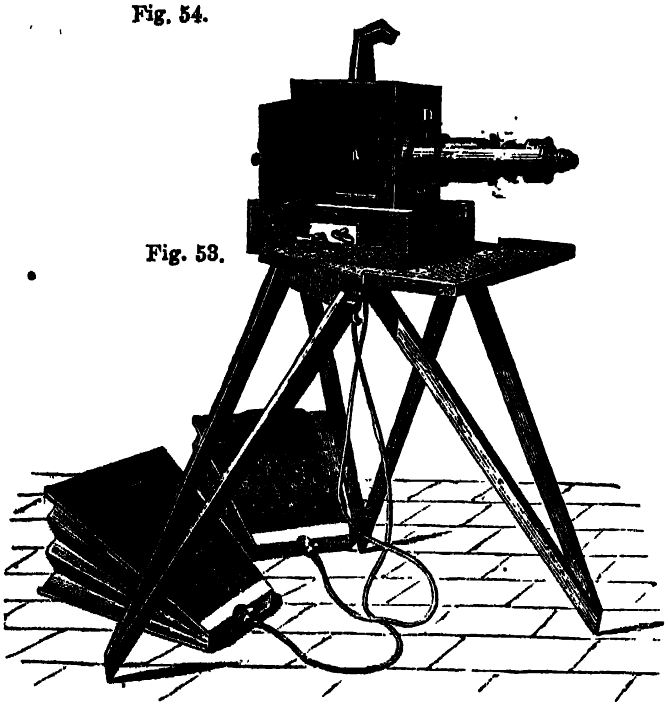


Fig. 53.

Pressure-boards.—When the gas-bags are required for use they are placed between two boards hinged together, out of which a semi-circular hole is cut to allow of the stop-cock projecting. On the upper board a ledge is fixed, on which the necessary weights rest. This method of arrangement is shown in Fig. 53. As such boards make a very awkward package for travelling—the smallest-sized bag suitable for an ordinary lantern exhibition should hold six cubic feet of gas, and measure about 36 inches in length by 24 inches in breadth, and 24 inches in the deep part of the wedge—I arranged the pressure-boards to fold up by means of hinges, and when opened for use to be clamped in solid shape by hinged fillets and screw-nuts, as shown in Figs. 54 and 55. The weights usually employed are, half a hundred weight on the bag used for the oxy-calcium light, and *two* half-hundred weights on *each* of the bags required for the oxy-hydrogen light. To save space, the pair of bags are sometimes laid over each other, head to tail fashion, between pressure-boards made Z shape. Mr. Malden has introduced a better arrangement, as he not only saves space, but enables the operator to dispense with half the weights required with the old system, as only two half-hundred weights are necessary to produce the same amount of pressure. The bags are placed as shown in Fig. 56, which also secures a greater quantity of pressure. The direction of slope also carries away from the stop-cocks any water that may accidentally have been blown into the bags. To prevent the bags slipping out from between the boards, a piece of sail-cloth is fastened so as to lay between the bags, which by its frictional action holds them in place with a firm grip. It will be seen that a rack is provided for the adjustment of the bags at a suitable angle.

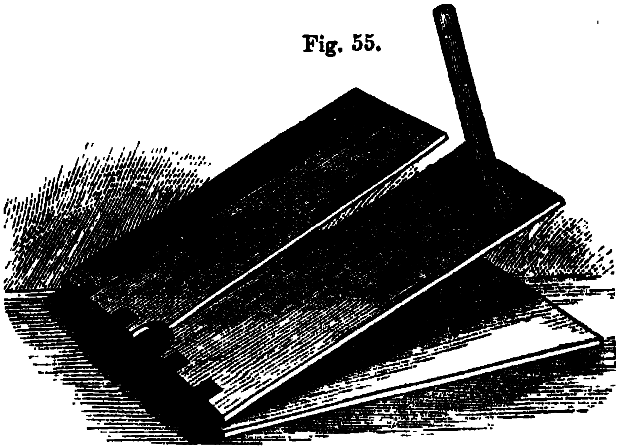


Fig. 55.

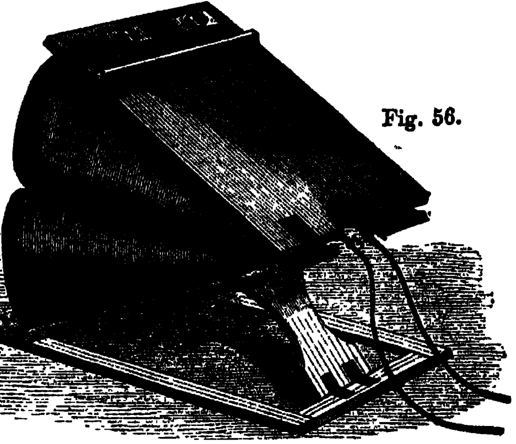


Fig. 56.

Weights are a great drawback to the gas-bag arrangements, for 1 cwt., much more 2 cwt., form serious impedimenta in a travelling lecturer's outfit; and though weights can generally be borrowed in every town, still it does not place the operator in that position of independence from extraneous aid which is always desirable. This objection, of course, does not obtain when the apparatus is employed at a fixed residence. Various suggestions have been made for replacing the solid iron weights with other contrivances, such as bags that can be filled with sand, earth, etc., but these form bulky substitutes in the lecture-room. A more practical arrangement would be a combination of stout india-rubber springs fixed to the boards, and a racked windlass to take up the slack as the bags collapsed, but it would require frequent attention to keep the pressure tolerably equal.

PHOTOGRAPHY.—II.

By J. C. Leake.

APPARATUS FOR PRODUCTION OF NEGATIVE PICTURES—THE CAMERA—BATH FOR SENSITISING PLATES—CHEMICALS—COLLODION—NITRATE OF SILVER—RE-DEVELOPER—METHOD OF FIXING THE IMAGE—VARNISH.

Having in our first chapter described the preparation of the photographic laboratory, or dark room, we now proceed to the description of the apparatus necessary for the production of negative pictures. By far the most important piece of apparatus for this purpose is the camera, of which we gave a brief description in our first outline of the collodion process. Cameras are made of every size and quality, and of various materials—those which are intended for studio work, where weight is no importance, being mostly constructed of wood; while those for field work and travelling are generally so made as to be light and portable, having bodies of a flexible material, impervious to light, supported by wooden framework. Although these latter are very convenient in travelling, for real hard work and certainty of action the old rigid wooden sliding-box cameras are much to be preferred, as the loose parts and intricate arrangements are very liable to get out of order, and so hinder or spoil the work. We should, therefore, advise the use of a camera of the required size constructed of mahogany, and if very much work is to be executed, a few shillings extra will be well expended in having every part of it clamped with brass. With respect to size very little can here be said, as of course this will depend upon the scale upon which the pictures are to be executed. It is well, however, for the tyro to commence operations upon moderate-sized plates, say about 8 by 6 inches, a size which, while it will prevent him from getting into a weak style of work, will, at the same time, be easily manageable. When a camera is purchased, it should be carefully examined in a strong light, in order to ascertain that there are no holes through which light may be admitted to the interior. This precaution will often save many failures. The next requisite is a lens, the selection of which will depend upon what kind of work is to be executed. Lenses for photographic purposes may be roughly divided into two classes—namely, single and combined; the former of these being generally used for landscape, and the latter for portrait work, or subjects requiring great rapidity of exposure. For ordinary landscape work, the single lens will in most cases be found sufficient; but for architectural purposes, and those in which great accuracy of delineation is required, the various combinations must be selected according to the requirements of the work. For portraiture, a double combination must be employed, which will combine a large aperture with good definition and great rapidity of action. It is perfectly useless to attempt to use one lens for many kinds of work. It is true that a lens will often answer for two or more purposes, but it is far better to employ each for the purpose for which it has been specially constructed. At the outset we should advise the purchase of two lenses—one double combination, for portraits and rapid work; and one really good single landscape lens, for copying and ordinary out-door work. Of course, we cannot here recommend any particular maker; but we may caution the purchaser against buying lenses of any but the very first quality. It is true that a good lens is expensive, but it is also most true that a really good one is absolutely necessary, and that one of inferior quality will in the end cost more than the best. The best plan for the amateur will be to consult some respectable optician as to his requirements, and be guided by his decision.

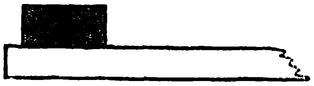


Fig. 3.

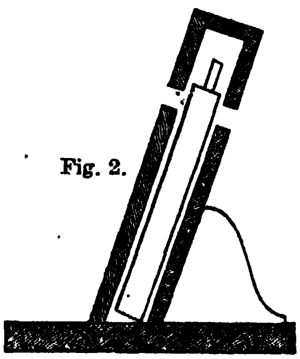


Fig. 2.

For the support of the camera, a suitable stand will be required, and, as in the case of the camera, the stands are made of different construction, according to the purposes to which they are applied; those for use in the field being light and portable, while those for the studio are heavier, and, of course, more steady and convenient for use. It is of the utmost importance that the camera should remain perfectly and absolutely still during the exposure of the plate, the slightest vibration invariably destroying the picture; hence the selection of a strong and rigid stand is imperative. Unfortunately, a passion for lightness and portability has led the makers of photographic apparatus to construct stands of so slight a kind that they vibrate easily in a strong wind, or upon the slightest touch; and it therefore becomes the operator to select such a one as will resist these influences, even at the expense of a little extra weight and loss of portability. The camera should always be secured to the stand by means of a screw, as well to prevent accidents by falling as to check any vibration. The next piece of apparatus requisite is a holder or vice, to support the glass plate in process of cleaning. In the ordinary form, this consists of two slips of wood, having a groove or rabbet upon their upper edges of sufficient depth to allow of the insertion of the glass. Through these slips are inserted two rods of brass or wood, which serve to keep them parallel to each other. In the centre, between these rods, is inserted a screw, by means of which the plate is secured in the rabbets during the process of cleaning. For the purpose of cleaning the glasses, which, as we have before remarked, is a matter of the utmost importance, a supply of cotton-wool and several cloths and leathers will be required. These must all be cleansed before use, by washing them in a cold solution of common washing soda, and afterwards in several changes of cold water, soap and grease being most carefully avoided. The cloths and washed leathers should be most carefully kept, in a box free from dust, and, above all, from grease, and they should not be used until after the hands have been well cleaned and dried. A broad brush of camel's hair should be provided, for the purpose of removing any particles of dust which may adhere to the glass immediately before it is coated with collodion. This brush must be as carefully cleaned and kept as the leather and cloths. After cleaning the plate, it should be placed in a properly made box, with grooves for holding the glass in position, the cleaned sides all being placed in one direction.

For the sensitising of the plate, a glass or porcelain trough will be required, of a size proportionate to that of the plates to be employed. Upon the whole, glass vessels are to be preferred for this purpose, in consequence of their superior cleanliness in use, as well as from the fact of their transparency allowing of frequent examinations of the solution which they contain, in order that it may be kept perfectly clean and free from floating particles of dust or collodion, which would adhere to the sensitive surface, and cause spots in the finished picture. When a glass bath is used, a wooden casing will be supplied with it, with a loosely-fitting cover, which should always be kept over it when not in use. The form of bath most frequently employed is shown in section in Fig. 2. In this bath must be a dipper for the purpose of raising and lowering the plate during the sensitising process. The dipper simply consists of a slip of glass of sufficient length to reach from the bottom of the bath to about an inch above the top, in order to afford a good handle by which the plate may be easily manipulated. Upon this slip is cemented a second at a slight distance from the bottom, as shown in Fig. 3, which forms a ledge upon which the plate may rest. The cover of the bath should be so high as to allow of the bath being covered while the dipper remains upright. A properly-made bottle for holding the collodion should also be provided. The best form with which we are acquainted is that in which the stopper is enclosed in an outer cap of glass, accurately ground to fit the outside of the neck of the bottle, so as to prevent any escape of the collodion solvents by evaporation. This is important, as if evaporation is allowed to go on, the collodion will speedily become so thick as to run unequally over the plate, and cause stains and cloudy markings. Several developing-glasses will also be necessary. These are simply small vessels resembling tumblers, but having a lip on one side to facilitate pouring. For the fixing of the image we should advise the use of a dipping-bath, similar to the one already described for the sensitising process; as if the fixing solution be merely poured over the plate it is apt to act unequally, as well as to render the hands so impure as to cause stains in subsequent operations.

Some operators recommend the use of a plate-holder during the development, but we are inclined to advise the careful handling of the plate by means of the fingers alone. A spirit-lamp is always a useful accessory in the laboratory, and will be found exceedingly useful in drying and varnishing the finished pictures. This will complete the list of apparatus absolutely necessary for producing a negative, and we may now proceed to describe the chemicals required, and method of using them.

Having provided himself with the apparatus that has already been fully described, the operator may now proceed to mix the requisite chemicals. In this matter the greatest care must be taken, as to the quantity, cleanliness, and purity of the weights and measures used and of the chemicals themselves. No guessing at the quantities can be permitted, as in some cases a few grains more or less will involve the certainty of failure. The operator should therefore provide himself with a pair of scales with glass pans, and weights from 5 to 500 grains. These, of course, can only be used for solids, and, consequently, several graduated measures of glass, varying from 1 to 10 ounces in capacity, should also be provided. After every operation, all measures, as well as the scale-pans, should be thoroughly cleansed, in order that no traces of the chemicals employed may be carried into solutions in which they are not required. Everything being thus in order, the operator may proceed to the mixing of the solutions.

The first thing requiring attention is the collodion. We shall not here describe the manufacture of this important compound, inasmuch as it is not likely that the operator will manufacture it for himself: we will hereafter describe the method adopted, and give the requisite formula. The best course of proceeding will be that of purchasing, say, one pint of bromo-iodised collodion of a good maker, asking that the collodion and the iodising solution be in separate bottles, in which condition they will keep an indefinite time. In order that the collodion thus procured may be rendered fit for use, it will be necessary to mix the two solutions; the proportions vary with different kinds of collodion, but that mostly adopted is 1 part by measure of the iodiser to 3 of the plain collodion. The quantities will, however, be plainly stated upon the bottles, and they must be strictly observed. Supposing, however, that the proportion of 1 to 3 is correct, proceed to iodise the collodion by pouring into a glass measure three ounces of the plain solution, measuring with the utmost accuracy. This, should then be poured into the collodion bottle before described. Now measure one ounce of the iodising solution in like manner, and having added it to the collodion, replace the stoppers, and shake the mixture for two or three minutes. After resting a few hours it will be ready for use; but it is better to allow an interval of twelve hours to elapse before applying it to the plate, in order that it may become thoroughly settled.

The next operation will be the preparation of the nitrate of silver bath used for sensitising the plates. In this matter, as in the last, great care is required as to cleanliness and purity of materials and measures, as the slightest impurity will inevitably produce failure and disaster. Carefully wipe the scale-pans before weighing out the nitrate of silver; and wash the measures in clean water, adding a final rinse of that which has been distilled. We should advise the operator to mix a good quantity of solution at once, as small mixings are always wasteful. Take of pure re-crystallised nitrate of silver (the ordinary common nitrate of silver will be of no use in this part of the process) 1,400 grains, which should be placed in a clean bottle, rinsed as the measures in distilled water, and add to this 20 ounces of distilled water; shake until the crystals are dissolved. To 20 ounces of distilled water, in a second bottle or measure, add 4 grains of iodide of potassium, and when dissolved mix the two solutions. A light cloudy precipitate will be formed of iodide of silver, which will speedily be re-dissolved upon the agitation of the whole. The solution should now be carefully filtered through two or three thicknesses of pure filtering paper, when it will be ready for use. Note that all solutions of silver must be made in distilled water, in order to prevent the precipitation of chlorides or carbonates, by means of the salts usually in solution in ordinary river or spring water. Also, that all filter papers, and those which have been used for absorbing waste silver solution, should be carefully preserved, in order that the silver they contain may be recovered.

The solution proper for the purpose of developing an image upon bromo-iodide of silver is one of the protosulphate of iron, which must be prepared in the following manner:—Take of pure protosulphate of iron 100 grains, and dissolve it in 10 ounces of water; distilled is preferable, but not essential. The solution of the salt will be readily effected if the crystals be pulverised in a mortar. To this solution add half a fluid ounce of glacial acetic acid, and the same quantity of alcohol; the whole to be well shaken and filtered before use. In very hot weather, or where the subject to be photographed is very intensely lighted, the quantity of acetic acid may be double that given above. The reason for adding the acid is that the iron alone would act unequally without some restraining power which would moderate its action; but, of course, if too much be used, the reduction upon the plate will be feeble. The alcohol is simply to cause the solution to flow evenly over the whole surface of the plate: it has no chemical action whatever.

The re-developer, or intensifying solution, consists of pyrogallic acid, in the proportion of 2 grains to the ounce of water, to which is added 1 grain of citric acid, for the same reason as the acetic acid is used in the first developer. The solution above given is simply for the purpose of adding to the intensity of the image obtained by the use of the first developer. It does not of itself develop any traces of an image after the application of the iron solution to the plate, although, from the density which it imparts to details which have been previously weakly brought out by the first solution, it frequently appears to do so. For use with the pyrogallic acid solution, one should be made containing 10 grains of nitrate of silver to the ounce, for which distilled water must of course be used. It will be hardly necessary to filter either of the two last-named solutions if care be exercised in their preparation.

The fixing of the photographic image—which, as we have before explained, consists in dissolving out the unaltered iodide or bromide of silver—may be effected by means of a solution either of hyposulphite of soda or cyanide of potassium. If the first-named salt be used, a saturated solution may be made by placing a quantity of the salt in a jug or basin, and pouring upon it boiling water. It should then be well stirred, and when cold the solution poured off the crystals. The best method of using this will be to provide a bath similar in construction to that employed for the nitrate of silver, dipping the plate in the same manner. The greatest care is necessary in order to prevent any trace of this salt being brought into contact with any of the chemicals in use, which it would inevitably render useless. Cyanide of potassium, although very much quicker in its action, and much more cleanly in use, is at the same time so dangerous and deadly a poison that we hesitate to advise its employment. Should this be determined upon, however, the salt should be dissolved in the proportion of 10 grains to the ounce of water, and kept in a closely-stoppered bottle, most conspicuously labelled, in order to prevent accidents. In the case of either hyposulphite of soda or the cyanide of potassium, common water will answer every purpose, and filtering is unnecessary.

In all probability, the operator will purchase the varnish required for the finished negative ready prepared, but we append the method of making one which is cheap and effective, in case he should wish to make use of it. Procure of the oilman or varnish-maker some of the varnish known as "best white hard," and dilute it with twice its volume by measure of methylated spirits of wine. It should then be well shaken and filtered, when it will be ready for use.

This will complete the list of preparations necessary for the production of negative pictures. We should advise the operator to prepare all the solutions required, and to carefully label the bottles containing them, as well as to definitely arrange the places where each is to be kept, before attempting to make any experiments; and although this may seem a tiresome task, he will find the advantage of this course as soon as he begins actual work.

We must again take the opportunity, in bringing this paper to a close, to direct the attention of the operator to the necessity that exists for perfect cleanliness in all operations connected with this useful and most pleasing art if he would command success. Without scrupulous attention to this point, the efforts of even the most skilful manipulator would be in vain.

GREAT MANUFACTURES OF LITTLE THINGS.—III.

BUTTONS (*continued from Vol. II., p. 391*).

BY CHARLES HIBBS.

We have now to speak of that class of button which is indebted to the turning lathe for its form. The most beautiful of all the substances used for buttons of this character is undoubtedly the shell of the pearl oyster, commonly known as mother of pearl. Those orient drops which serve our beauties for adornment, and our poets for metaphor, to so large an extent, owe some part of their attractions, no doubt, to the romance which attends the manner of their introduction alike to the light of day and to the world of commerce. Snatched from the bosom of the deep by adventurous divers, who daily peril their lives in abstracting those shark-guarded treasures of the sea, the shells, on being brought up, are eagerly and keenly scanned for the coveted pearls, which occur very few and far between. But the shell itself, which is quite a secondary object of the diver's regard, is destined to serve a purpose, more homely perhaps, but to all intents and purposes more useful, than the treasure it so very rarely encloses. The unpretending little buttons which serve as fastenings to the fronts of our shirts, are made out of shells fished up from coasts widely separated from each other, and are of correspondingly differing qualities. The best are gathered from the seas around Macassar; those of the next quality come from Manilla; a third, of a still commoner kind, are found in the Persian Gulf and in the Red Sea; and a fourth, the poorest of all, are brought from islands in the Bay of Panama, called the Pearl Islands. There is another kind, of a black colour, brought from the Archipelago of the Pacific, certain portions of which, when the black surface is turned off, will yield white buttons of a quality not inferior to the best Macassar; and at one time this constituted the entire commercial value of the shell, the black portion being thrown aside as waste. But capricious Fashion, which in its way makes more revolutions than war, decreed that black pearl buttons, for coats and vests, should for a time become the rage, and straightway the heaps of refuse, which had in many cases been buried to get it out of the way, acquired considerable value. The substance had a clear title to public favour, being very beautiful; and a set of picked buttons, highly polished, would shine with as many tints as the chameleon in different lights. Black pearl buttons are still extensively used for ladies' mantles, etc., and, turned of very small size, for ornamenting the tops of boots.

The mode of their production is simple, but involves considerable skill of hand. The first workman is called the "piece maker," and his duty is to cut out the blanks from the shells. A short tube of steel, the diameter of the button, with one end cut round its edge into a saw, is fixed in a common foot-lathe. He holds the shell firmly against this cutting tool while it is revolving at speed, and with some moderate pressure exerted, it cuts pretty rapidly through. Of course the largest buttons are cut out of the middle and thickest parts of the shell; the thin sides being available for the smaller sizes. The best workman is he who can cut up the shells to the best advantage. These blanks, or "pieces," have then to be "bottomed," which means taking off the rugged outside of the shell—that on which the waves have been beating—by means of the turning tool or the file. This will generally be the under side of the button, and, if turned, it is of a convex shape. The workman has a "chuck" of box-wood in his lathe, slit down with a saw to half its length, with a screw-clamp upon it to tighten it up. On the end or face, he has turned a little recess, corresponding to the size of the button, and when he has prized open the slit with a sort of jemmy, and inserted his pearl blank in this recess, it is held quite tightly enough for his purpose. The turning tool is a triangular chisel of steel, pointed at the end. The pearl shell being very hard, this chisel requires to be frequently sharpened, but when in good order it takes off the superfluous material, in the shape of fine dust, very quickly. The bottoming is done mostly by boys, and is good training for the more skilled operation of turning proper, which consists in putting the face or pattern on the button. The inventive genius of the pearl button-maker is concentrated on the very limited superficies contained in one side of a button. It has no other field for its exercise. The number and variety of shapes which he has succeeded in producing would seem impossible to a stranger. By the skilful guidance of the cutting tool, now applying the point, and now the sharp edges of the sides, the turner speedily hollows out the button into a graceful cup, undulates its surface into hills and valleys, or forms rim and centre into bold plateaux, relieved by deep recesses. There is room for some exercise of the artistic faculty in devising even the shape of a pearl button, the skill being shown in bringing out the colour of the shell by light and shade. The pattern-books of some makers will show common and vulgar, while those of others will be chaste and pleasing. The remaining processes are done by women. They consist of "hubbing," drilling, and polishing; the first named being the grinding out of certain little nicks or hollows which are supposed to give ornament. All these are performed in the lathe.

Pearl buttons for outer garments are now largely superseded by those called vegetable ivory, which have a no less curious parentage. They are made from an odd kind of nut, called the Corozo nut, which grows in clusters upon a species of palm-tree in Central and South America. In size and general appearance it is not unlike the potato, and a casual passer-by, on seeing a wagon-load of them shot down at the door of a button-maker, would think he was laying in a stock of that useful vegetable for winter. It is seldom solid throughout, being mostly decayed in the middle, and is something harder than wood, but not quite so hard as ivory. When sawn through, a good nut is a beautiful milky white, very clear and transparent, but exposure to the atmosphere soon destroys the delicate purity of its complexion. It will, however, readily take any tint in the dyer's vat, and this facility, which enables it to be made of a colour to suit the garment, is, combined with its neat and chaste appearance, the secret of its great favour with the public. This very beautiful and manageable substance has been known in the button trade only about fifteen years; some few ornamental articles, such as beads, etc., having been occasionally formed of it before that time. Ever on the look-out for novelty, the button-makers seized upon it eagerly, and at present the consumption of nuts by them in Birmingham alone is certainly not less than twenty tons per week. The material seems eminently adapted for many other small articles than buttons, and if the supply can be relied upon, there can be no doubt that other spheres of usefulness will speedily be found for it.

The first thing done is to strip the nut of its outer husk, which, being thin and hard, easily breaks and shells off, raising clouds of dirty brown dust. It is done by young urchins who are known as "nut-crackers," and who form perhaps the lowest class of labourers to be found in the trade. Mr. J. P. Turner, of Birmingham, says, "Every little rascal who is too wild for steady work can be set to do this; and consequently they are the veriest little Arabs to be found in any branch of industry, their destructive propensities being happily utilised in the manner described." The nuts are then cut up into slices by a small circular saw, and afterwards converted into buttons by a very expeditious and summary process. A tool, somewhat similar to a centre-bit, is fixed in a lathe; its cutting edge has been indented to correspond exactly with the pattern of the button to be cut; the workman presses upon it the slice of vegetable ivory, and while it is cutting the face, brings up with a lever an opposite pulley containing the tool which cuts the back. Both sides of the button are thus turned at a stroke. The white feathery shavings fly in all directions, and the workmen engaged in this operation look as though feather-beds had been emptied over them.

Bone buttons are produced by methods sufficiently similar to the above to enable us to dispense with a detailed description, as are also box-wood buttons, which are made in large sizes, and dyed, for police and military overcoats, etc. Ebony, kingwood, and other expensive woods, are treated in a manner somewhat different. The buttons are turned and cut from a wooden bar. Say that the button is to be an inch in diameter. A length of a few inches has to be cut from the log of ebony, and squared on the saw-bench to one inch; the end is spigoted to drive into the headstock of the lathe; and then the turner, having roughly taken off the corners to save himself trouble, turns on the end of the bar the semblance of a button, and having got the face finished to his liking, nicks the bar behind it with a sharp pointed tool until it is cut through, and the button tumbles off.

in this manner he cuts his way down to the lathe, when he turns out with his chisel the bit of wood wedged in.

We may now proceed to examine the methods of producing buttons made of plastic materials, which generally owe their form to pressure. The foremost place in this category must be given to the horn, or more properly speaking, the *hoof*, button, the material being the hoofs of cattle boiled down to a sort of thick pulp. This kind of button can boast of a venerable antiquity, and large quantities were made, and sold at a very low rate, at the beginning of the present century. Hutton, the quaint historian of Birmingham, speaks of "the cloaks of our grandmothers, ornamented with a horn button nearly the size of a crown piece, a watch, or a John-apple curiously wrought." These, no doubt, were clumsy productions compared with those of the present day, which are in many instances distinguished by taste and elegance. Some of the designs are of the most elaborate character, full of fine detail; the soft material taking the print of every delicate line in the die. Unfortunately, this sharp and clear impression soon begins to wear off, and after a time the horn button becomes as smooth as an old sixpence.

The dies in which they are moulded are of brass, highly polished. A number of presses are ranged round the shop, each containing the top and bottom dies, or matrices, of the button. The operator, commencing at one end, puts a small quantity of the warm and plastic material into the mould, brings down the top die upon it with considerable pressure, and leaves it there. He then goes on to the next, and so on to the end, by which time the first button is cooled sufficiently to be taken out. The edges have afterwards to be trimmed, and the buttons are completed. The shanks, if any, have been previously placed in the dies, and the material presses round and encloses them, so that the attachment is perfectly complete. If it is a large size button that is being made, each press encloses but a single one; but for smaller sizes, the die may have a row of holes, each exactly the counterpart of the other. It will be seen that the skill and ingenuity consist, not in the actual making of the buttons, but in the execution of the dies; and it will perhaps be proper to describe the manner in which any required numbers of them are obtained in exact duplicate, although the description properly refers to another trade, that of die-sinking.

In the first place, a die is sunk in steel in the ordinary manner. When it is hardened and polished, a piece of red-hot steel is driven into the impression by repeated blows of a stamp. If properly done, the precise print of the die can be obtained upon this "hub," as it is called. At this stage, an opportunity occurs to enrich the design by the short cut of practising on the hub. For instance, if it is intended that the button shall have incised marks or letters upon it, or if any part of the design is to be sunk in its surface, now is the time to insert those particulars. If they were actually cut in the matrix, each of the intended depressions being left standing in relief, it would necessitate endless labour; but they can be struck in the hub, by means of punches, with very little trouble. All that is wanted is to finish up the hub to be the exact counterpart of the features of the intended button in every particular. Then, when it is in its turn hardened and polished, it will strike any number of matrices, from which countless millions of buttons can be made, all microscopically alike.

Porcelain buttons, which are not now made in England at all, are also fashioned in moulds. Thirty years ago, the idea was first introduced by a Birmingham man, Mr. R. Prosser, and taken up by the celebrated Staffordshire potters, Messrs. Minton and Co. The French, for some reason or other, took warmly to the trade, and probably by the unscrupulous use of child labour, drove their formidable competitors out of the market, and now have it all to themselves. There is nothing remarkable about the buttons, except their cheapness. The present wholesale price is about 9½d. for a great gross, viz., 144 dozen, neatly sewn on good paper, and made to look spruce.

Some kinds of glass buttons are moulded, or pinched, by methods not differing sufficiently from those described to call for further description; but there are other ways of producing them, which may be interesting. One method is identical with that which is used for making glass beads—indeed, the buttons *are* beads, fitted with a shank. Coloured glass is drawn into rods of the required gauge, each rod having a hole down the centre like that in the stem of a tobacco pipe. The workman breaks off a piece of this rod, threads it on a wire, and sitting down before a lamp, directs a jet of flame on to the end of it with a blow-pipe, and melts a piece off. He twirls round the wire with his fingers, and the fused bit of glass assumes a globular form by the cohesion of its particles. The shanks are affixed in an ingenious way. A piece of fine wire is doubled up close, and on the double end is soldered a small round plate, or "collett," not much bigger than a good pin's head. The bight of the wire is then passed through the hole in the button, coming out a little way on the opposite side; the collett preventing it from slipping completely through, and forming an ornament for the top of the button. A second collett is passed over the projecting wire, and pushed up close to the under side of the button; and then the loop is opened out to form the shank. The method of making solid ball buttons of glass, with shanks attached, is no less ingenious. The shank is formed first, of bent wire as before, with a little length to spare in the two ends; these are then spread out a little in the shape of a V; the loop of the shank is fixed in the lathe, and while it is revolving, the workman melts off upon it, with a gas-jet and a blow-pipe, sufficient glass to make a button, from a thin rod which he holds in his hand. The glass wraps round the wire in a ropy form, just like so much melted sealing-wax, but a few turns under heat makes it fall, of its own accord, into a true spherical shape, perfectly smooth and seamless.

These last two varieties of button, though we have included them in our third class, as being made of plastic material, do not owe their form to pressure. We have now to speak of one, which, though pressed into shape, is not made of plastic material. This is the papier-maché button. It is principally used for children's boots and shoes, and is consequently made only in small sizes. The blanks are cut out of sheets of thick pasteboard in the ordinary manner with a press, the punch at the same time making a stab in the centre of the disc to receive the shank. The shanks are stuck in by children, and the soft button, which is no more than a bit of brown paper, being put under a heavy press, and subjected to a powerful squeeze, is compressed into shape, and becomes as hard and smooth as ivory.

Such are a few of the processes in vogue in this remarkable industry. We have only aimed at describing the leading features of those which appear to head the groups, their modifications being so numerous as to make it hopeless to try to bring any detailed account into reasonable compass. A mere list of the various kinds, patterns, and designs of the buttons now in the market would fill several numbers of this periodical. It is hoped that what has been written will enable the reader to comprehend sufficiently the main principles of button-making. A few words as to the position of the trade in this country may not be inappropriate in conclusion. It is far from being one of our monopolies, or even one of our specialities. Mr. J. P. Turner, the authority before quoted, puts down the number employed in all branches of the trade in Birmingham at about 6,000; a total which would not be materially swelled by including the whole kingdom. The French Official Catalogue of the Exhibition of 1867 stated that the number then employed in France was 22,000; and further, that the industry, comparatively insignificant thirty years before, had made extraordinary progress, and that France was then furnishing to the civilised world by far the greater part of the whole button manufacture. Mr. Turner, on the other hand, supposed that "the quantity exported from *Germany* to other countries must far exceed that from both England and France together." We are, therefore, completely distanced by two competitors. The causes of French supremacy are not far to seek. In an article susceptible of such infinite variety of design and ornamentation as a button, the high art education of the French, their natural aptitude, and long experience in the production of elegant trifles, find a most convenient opportunity for their exercise. The result is, that they have established a reputation for the artistic varieties with all the buyers of the world, and these, also attracted towards Paris as the Mecca of fashion, seek to complete their purchases without coming to England. The German buttons only excel ours in cheapness.

By way of contrast to the cheap porcelain buttons before mentioned, we may refer to the once fashionable steel buttons, cut with facets, which used to be made and sold by Matthew Boulton at 140 guineas the gross!

SOLDIERING.—I.

BY A STAFF OFFICER.

SYLLABUS.

MATTERS to be considered in the organisation of every army—

A. Preparation of individual soldier.	I. How men are obtained for it. II. How they are equipped. III. How they are trained.
B. Building up an army out of the individuals which compose it.	IV. Units of command. V. The higher organisation, from the first units into new commands. VI. Supplies, and means of obtaining them.

I. Means of obtaining men:—Voluntary enlistment; compulsory enlistment.

II. Equipment. Subdivided:—
- (*a*) The agents employed by men in actual fighting.
- (*b*) Clothing.
- (*c*) Immediate necessaries.

(*a*) The active agents in war—
- (1) Fire-arms, large and small.
- (2) Hand-to-hand weapons.
- (3) The horse.

How the progress of invention has affected the qualities which are of the greatest value in a soldier.

How the present condition of arms and the use of the horse cause the subdivision of armies into the three great branches or "arms" of the service—
- (A) Infantry.
- (B) Cavalry.
- (C) Artillery.

The division into the three arms must be taken into account in considering the conditions which fix the nature of the clothing and immediate necessaries of each arm—
- (1) What is essential for all arms.
- (2) What conditions must be attended to in the equipment of each arm.

III. Training:—
- (*a*) Discipline.
- (*b*) Drill.

IV. Units of each arm—
- *Infantry:* The battalion, space occupied, what fixes it.
- *Cavalry:* The squadron, space occupied, what fixes it.
- *Artillery:* The battery, its strength, how subdivided.

V. The higher organisation of an army, from the units into new formations. Proportion necessary to be observed between the arms. Organisation of—
- (*a*) Infantry.
- (*b*) Cavalry.
- (*c*) Admixture of artillery with these.
- (*d*) Completion of the whole into regiments, brigades, divisions, corps, by the addition of engineers, etc., and the action of a proper staff.
- (*e*) Organisation actually adopted by various nations during recent wars.

VI. Organisation of the non-combatants. Main points to be considered:—
- (*a*) Supplies for an army. What these include; conditions to be fulfilled. What experience has taught as to the best means of obtaining them.
- (*b*) Transport—railway, water transport, road work, wheel-carriages, pack-animals.
- (*c*) Care of sick and wounded. Principles to be attended to.
  - (1) Hospitals, their necessary subdivision of classes.
  - (2) Transport of sick and wounded, and of stores necessary for them, special care for the removal of sick and wounded from the field.
  - (3) Organisation of medical attendance.

INTRODUCTION—OBJECT OF THESE PAPERS.

WHAT AN ARMY IS—THE FIRST NECESSITY FOR EVERY ARMY IS ORGANISATION—WHAT WE MEAN BY "ORGANISATION."

The following papers are intended to fulfil, as to that business of "soldiering" which has of late years threatened to become so terribly important a one in Europe, the same purpose which the other papers of these volumes have accomplished for other businesses, arts, and trades. There have been already papers contained in THE TECHNICAL EDUCATOR which were chiefly interesting to those who wished to know something of the employments of soldiers—of the arms they use, and of the fortifications which they attack or defend; but the subjects to which a soldier's attention has now-a-days to be directed are so numerous that these, and not a few other matters, can only be considered as branches of the great business on which he is occupied.

In order to understand what a soldier is, and what he has to do, it is necessary to become acquainted with him as a member of the great body to which he belongs; and to know what is required of him, in order that he may do his duty in it. The connection of the different subjects which he has to study, and their bearing on his main business, will then become apparent.

All a soldier's work is either a small contribution on his part towards the common efficiency of the whole army, or a preparation for performing his part towards that end; and it is, therefore, as unsatisfactory to study his individual duties without examining the constitution and nature of the body to which he belongs, as to examine the work of a finger or a thumb without any study of the hand or the arm, of which it is a member. But if it is impossible to become acquainted with the real nature of a soldier's calling without thus getting to know something of the nature of an army, it is still more hopeless to study what is called the "Art of War" in its higher features—to attempt, that is, to comprehend why battles and campaigns are won and lost, without a thorough acquaintance with the manner in which armies are held together, and with the conditions of their effective action. For battles and campaigns are not fought with collections of men who start from their homes in the morning, engage in a struggle of physical strength in the afternoon, and return to their homes in the evening, but by bodies so organised and prepared for action that they live under conditions of existence altogether different from those of the individual men of which they are composed, and yet are entirely created by the aspect which the necessities and characteristics of the bodies and minds of men assume, when they are brought into the strange new organism which is created by the moulding into one homogeneous whole of their several individualities.

A variety of questions have sprung up in regard to the army of late years, which all who take an interest in the future of their country wish to be able to answer correctly. Hardly any of these are answered by attempting to give an account of the several parts of the studies on which a soldier is necessarily engaged. Almost all of them will be understood if the nature of an army is properly considered. Of these, some of the most important may be noticed, as they will make the object of our work much clearer. We will put them in the form in which we have heard them. "How can sensible men take any interest in what is at best only a dreary preparation for a duty which may never require to be undertaken?" "What can be the use of sending our volunteer battalions down to a review where they do nothing but march, and never fire a shot? Who is to blame that this is all that they learn?" "Can our army march? and is it a proof than an army can march because our regiments, batteries, and squadrons are as well up to their work as any in Europe, or is something else required to enable an army to march, which has nothing to do with the power of the men to walk long distances, endure fatigue, and know their drills well?" "What are the advantages and disadvantages of compulsory service? Is it economical?"

An army is the instrument by which the rulers of a nation endeavour to give force to their views and wishes in dealing with other nations. In considering, as we are for the moment doing, the object with which those who create the army will set to work, it is irrelevant whether the rulers of the nation are, as is the case with a free people, simply the representatives of the nation itself, or whether a despot handles the resources of the country for his own purposes. In either case the object will be to develop the force in such a manner that it shall act only under the impulse which is imparted to it by the will of the ruler, and yet shall be as powerful an instrument as possible in the hands of him who wields it. This result has, in fact, to be obtained by utilising the services of an immense body of men, each of whom has as strong an inclination as men in general have to carry out his own wishes, and no one else's. Moreover, without any very special preliminary test as to courage, we intend to exact from these men an indifference as entire as we can possibly obtain to another question, on which most men are a good deal interested—their lives.

Again, as in order to obtain the object for which the army is to exist, the prime duty of these men will be to fight, they will not be able when actually on a campaign to perform effectively for themselves any one of those duties which men usually undertake in ordinary life; they cannot see that proper supplies of food and stores of all kinds are present at the spot where they need them, and some means must be taken to secure their constantly having them at hand when they need them, otherwise they will not be able to fight at all. All these and many more matters have to be well considered, and in the result an army has to be rendered at once as self-dependent as it can possibly be; as able to act as a single unity, and yet the fully-developed force of every individual must be put forth to the utmost possible extent, in order that the common force may be the greatest possible. The means by which these results are brought about is what we call the *organisation* of an army. I am anxious for a moment to insist upon the word, because an army is often likened to a machine, and I have myself spoken of it above as an instrument. An army may so far be an instrument that it is used for a specific purpose, but in so far as its interior economy and working is concerned, it is marvellously unlike a machine, and marvellously like a vast living body, instinct with a most definite life of its own, in which the duties of the several *organs* are as distinct as they can possibly be, and yet in which no small part of the duty of each is to co-operate with every other for the common end of the efficiency of the whole body, and in which the object of him who would develop its force is to bring out the full effectiveness of every organ in the highest possible degree.

SANITARY ENGINEERING.—XIV.

THE VENTILATION OF HOSPITALS.

In our previous papers on this subject, we have treated the ventilation of private houses and public buildings, and we now devote a paper to this special heading as one of unusually general interest at the moment, giving some practical examples of the different systems adopted. The first instance we select is that of the New Infirmary, as it is called, erected for the Wandsworth and Clapham Union in the course of last year. Natural ventilation only is employed; there are neither special furnaces, steam-power, or other mechanical aids; and we take as an example, a single ward 123 feet long, 24 feet 6 inches wide, and 12 feet high.

Standing out clear in the centre of the room, and about equidistant from each end, are two upright chimney breasts, each with two open fireplaces, one on each side, facing the long way of the ward; these have a flue unconnected with the smoke-flue, running along and under the floor, and communicating with the external air entering at the back of the stove into a chamber constructed for the purpose; and the fresh air, thus warmed, passes out into the ward by openings in the front of the upper part of the stove. Immediately above these gratings, which are made of terra cotta, there are others exactly similar, also communicating with the air outside, but from a totally different direction. The smoke-flues are constructed on the principle illustrated in our last paper—*i.e.*, at each angle of the circular flue there is a small air-flue, which in this case runs up to the roof, where there is a chamber specially built, and open on all four sides to the external air, enclosed, however, by gratings of open terra cotta, and from this a constant down-draught of fresh air is maintained into the ward. Again, in each pier between the windows on both sides of the wards are Sheringham's ventilators (as described in Vol. III., page 22), regulated by lines under the control of the nurses, and opening through the wall directly into the external air.

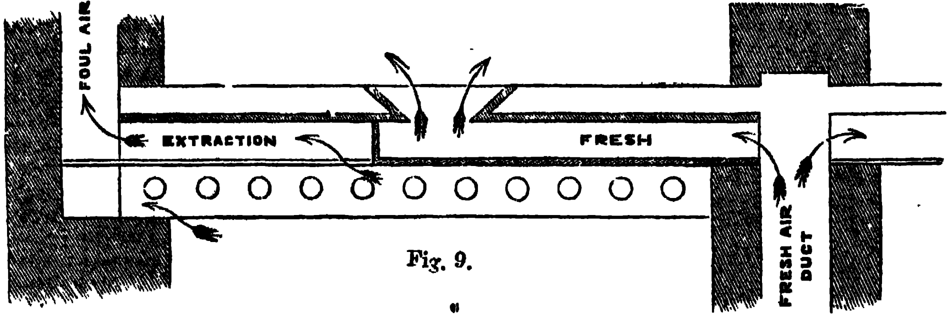


Fig. 9.

It is, however, a well-known fact in hospital experience, that certain classes of gases generated in disease are heavier than the ordinary atmosphere, and fall to the ground; these, if undisturbed, accumulate under the clothes below the bed as under a bell-receiver, and as in the ordinary course of traffic nurses pass by the bed, are occasionally disturbed and set moving about the room. In this case under the head of each bed there is fixed an ordinary "hit or miss" ventilator of metal, opening direct through the wall into the air; by opening this a few minutes at any time the gases are freely dispersed and removed by the ordinary exits of foul air. Lastly, as a sort of perpetual safety-valve, there are flues in the external walls running up to the roof, opening into the ward by self-acting valves, somewhat similar in construction to those described as Dr. Arnott's (Vol. III., page 22). These flues are calculated at one inch of area for every fifty cubic feet of air contained in the ward, and lead into the open space contained within the roof, which acts as a hot-air chamber, and has louvres at the ridge by which the foul air finally escapes. We may mention here that, as an additional precaution, the drains are ventilated by separate flues that run up in towers to a height considerably above the general roof level, and that a receptacle for charcoal is provided at the top of each flue as a disinfectant.

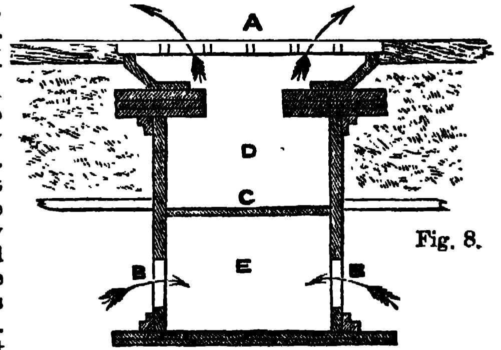


Fig. 8.

Having described one of the most perfect of modern systems for what we call natural ventilation, we now proceed to give the detail of one or two others where artificial aid is employed, and we next take up the new buildings at Guy's Hospital, of which the first portion with the central tower was erected about eighteen years ago, the other wing having been completed last year. In this case there are three lofty shafts, two for the admission of fresh air, one on either side of the principal entrance, and the third towards the centre of the building for the extraction of the foul air and the exit of the smoke at a level very much above the height of the other towers, from which it is situated at some considerable distance. From the top of the admission shafts the fresh air is carried down to a chamber in the basement, where it is heated by passing over a series of hot-water pipes, and then ascends by numerous flues contained in the brick piers in the centre of the wards. The wrought-iron box girders that carry the various floors are here brought into play, and contain both the admission and extraction flues (Fig. 8). There are twenty-two of these girders in each ward, and the longitudinal section (Fig. 9) shows the course of the air.

The upper flue, embedded in the concrete of the floor, admits the fresh or warm air as required by gratings in the floor; and the lower flue, which is immediately below the ceiling of the wards, receives through a number of circular apertures the vitiated air from the ward below, which is then carried by a series of independent flues to the vitiated air-chamber in the attic storey, and thence to the great shaft in the centre of the building.

In the portion of the building erected some time ago a system almost directly the reverse of this is in operation as regards the admission and extraction of the air, though the general arrangement of the flues as far as the building construction is concerned is very similar. The fresh air is introduced by gratings in the walls close to the ceilings, and extracted afterwards through gratings in the walls near the floors and immediately under the heads of the beds. There is something to be said in favour of the latter system; but so long as there is a thorough change of atmosphere, and the temperature is pleasant without draught, it does not materially matter how the change is accomplished. The experience of a year or two will doubtless prove beyond a doubt which of these two diametrically opposite systems of air currents is to be preferred. The heating apparatus in the basement is only supplementary to the open fireplaces, of which there are four in each ward, as well as another in the ward kitchen, the ground floor having open fireplaces only, and the upper floor or dormitory hot-water pipes circulating through its entire extent. There are varying modifications of this system of warming adapted to the museum, the grand staircase, and other portions of the building, into the detail of which we need not here enter, as the general principle upon which they have been carried out is already sufficiently explained in our previous paper on warming by warm water.

A general description of the arrangements would be foreign to our present purpose, which includes only an explanation of the general principles adopted in the arrangement of the ventilation.

We conclude our short series upon this subject by an account of the system adopted at the last erected and largest of the London hospitals—viz., St. Thomas's, adjoining Westminster Bridge, which we may say combines the advantages of the natural and distributed system, with the introduction of artificial aids to ventilation in detail.

Taking a single ward as a sample of the whole, the arrangements are as under:—There are three fireplaces in the centre, facing endways of the ward, and the heat of the fire is made available for the up-draught of an extraction-flue which surrounds the smoke-flue of each particular chimney with an iron casing, and removes the foul air through a grating at the ceiling level; fresh air is supplied to the fire and the ward by a flue running within the levels of the floor, and communicating directly with the external air, which is warmed by its entry into a hot-air chamber behind the fire before it is admitted into the room. The pavilions of the hospital are large blocks of building, of which each floor forms a ward with its necessary adjuncts, lavatories, etc., nurses' rooms, and kitchens, and to each pavilion is provided a separate and complete set of hot-water apparatus, having its boiler and furnace in the basement storey; the flue from this is carried up to the turret level in an iron tube which forms the centre of an air-shaft or extraction-flue for the block to which it belongs; and on each floor are two large coils of hot-water pipe in addition to the open fires, each coil supplied with fresh air by a separate air-duct contained within the level of the floor, and drawing its supply from a grating in the external wall. From the ceiling and floor level there are also separate gratings communicating with specially constructed flues, all of which lead into the one central extraction shaft annexed to the smoke-flue of the hot-water apparatus in the basement of each pavilion.

The sources of supply of fresh air, or the fresh air-ducts, are therefore two in number:—

1. The flue from the external air communicating with the back of the stoves, three in number in each ward.

2. The flues that communicate in the same way with the hot-water coil, two in number in each ward.

The extraction ducts are of two descriptions:—(1) Those surrounding the flue of the open fireplaces, three in number, running up to a chamber in the roof, and communicating with the main extraction shaft from top and bottom of ward. (2) Those connected by flues with the same extraction shaft containing the smoke-flue of the hot-water apparatus, of which there is one provided to each pavilion in the area of staircase adjoining the shaft of the lift from top to bottom.

The three examples quoted illustrate different methods of ventilation: the first, the Wandsworth Infirmary, showing what may be called the natural system, in which the common open fire is the only assistance to the ordinary admission of external air. The second, Guy's Hospital, exemplifying the introduction of what we may call a complete system of artificial ventilation throughout the various floors of an extensive building arranged and constructed so as to be under entire control.

The third, St. Thomas's, while availing itself of the powers conferred by either system, preserves the control in detail, which must sometimes be desirable in individual wards. All these various combinations work satisfactorily, and no doubt, if it were desirable, we could furnish many other examples of varied methods for the introduction of fresh air and the removal of foul; but if this paper is read in connection with our two previous papers on ventilation, and also with that on heating by hot water, any details necessarily omitted for want of room may be easily supplied, and we here complete our series of articles on this subject to proceed to the equally important sanitary topic—viz., drainage.

SILK CULTURE.—II.

By Alexander Wallace, M.D.

TIME FOR HATCHING — MANIPULATION FOR HATCHING — FEEDING WORMS IN EARLY STAGES—PAPIER FILETS AND NETS—SUCCESSIVE MOULTS OF WORMS.

Early in the spring, on a warm sunny day, it is usual to wash the eggs with water at a temperature of 65° to 70° Fahr. Red wine is sometimes used for this purpose. The eggs are then dried in a warm room, but without a draught. Early in April, in Italy, the eggs hatch out; in France, early in May; and in England, the first week in June. If the eggs are kept in a cool, airy, dry cellar at a temperature of 50° to 55°, there is no fear of their hatching out prematurely; but at a higher temperature they will very probably do so. Towards the end of May, when the weather is warm, bring them out into the *magnanerie*, gradually raising the temperature 5° daily, till 70° or 75° is reached, at which temperature the eggs will hatch. A higher temperature is recommended by some, but I have found my eggs hatch out remarkably well at 60° to 65°.

The manipulation necessary for hatching out is as follows:—Light a fire in the stove of the *magnanerie*; in the evening place the cloth or card on which the eggs are laid; or if loose, place the eggs in a thin layer on linen, on a table near the fire, and cover them with muslin net. Ordinary cap net is admirably adapted for this purpose, of a size sufficiently small to permit the worms to creep through easily. Early in the morning the worms hatch out, at first one or two only as forerunners; then, perhaps, the next morning fifty or sixty worms, and then they hatch out in bulk. In three or four days, or at most a week, the worms ought all to have hatched out. It is a matter of great importance to keep each day's hatch separate, as, theoretically speaking, those born on the same day ought to pass through all their changes together, and spin their cocoons on the same day; but this is rarely seen in practice, though it is possible for the bulk to pass their changes at the same time; a card, therefore, is placed with each day's hatch and the date written thereon, and each moult is noted on this card, which gives, so to speak, the life-history of that tray. The worms having hatched out, crawl speedily through to the upper surface of the net, and may then have some finely-cut leaf scattered over them thinly; and as some worms hatch out during the morning, I do not remove the muslin net till midday, when it is placed with the worms thereon, on a newspaper, in the position it is to occupy as No. 1 tray, during the life of the worms; a fresh piece of net is then placed over the eggs. Should any more worms hatch out, pieces of cut leaf, of a little larger size, are placed near them; on these they crawl, and are then easily removed by a pair of forceps to their companions. This process is repeated day after day till all the eggs are hatched out, or nearly so, and each day's hatch numbered consecutively. It is not worth while to keep the few early or late worms, the care and trouble expended on a tray containing few being greater than that expended on a large number. It is desirable, therefore, to have trays which are well filled with worms. It is well also to be provided with double the weight of eggs intended to be raised—viz., to have 20 oz., where it is intended only to rear 10 oz.; for unforeseen losses may occur, or some worms may be lost through disease, which, if there are no spare eggs, cannot be replaced; therefore, as eggs cost much less than worms at any age, and as the care and trouble of feeding small worms, as well as the expense of leaf, is at its minimum, it is real economy to provide a double portion of eggs. The fresh young shoot of the mulberry may be gathered and given to the young worms, cut fine with a knife or scissors, or by means of the mulberry-cutter, a machine made like a chaff-cutter, which greatly economises the labour of preparing the leaf. It is, however, scarcely worth while to use this machine for the first age, except where very many worms are kept, as enough food can then easily be prepared by means of scissors or knife and a chopping-block; the leaf should be cut up in pieces not larger than the size of a pea or bean, and may be given four times daily—at six a.m., at ten a.m., at two p.m., and at six p.m. There is a great art in distributing the cut leaf to the worms; the object being to give them just as much as they will eat, and no more; too much leaf will be wasted, the worms crawl on to it and soil it; and if this accumulates in a moist state, it is apt to decompose and emit a noxious vapour very deleterious to the worms. The bed on which the worms rest, consisting of their excrement and of the unconsumed food, especially the stalks and ribs of the leaf, should be so crisp and dry that no effluvium can arise, and no gases be generated. When the bed reaches to the thickness of a quarter of an inch, it is time to give the worm a clean bed. This is accomplished by spreading over the worms, early in the morning, a net having meshes just wide enough to allow the worms to pass through easily; on this new bed fresh food is lightly sprinkled, and the worms crawl through or "rise to their food" with great zest. At noon the net may be lifted off, with the worms and their fresh food. Should any worms remain behind (*retardaires*), they are weakly ones, and may, if the stock be abundant, be thrown away, as not worth further trouble, or if required, a spray of mulberry may be placed over them; on this they crawl, and may then be removed, but not to their former companions; they must be put back a stage to the next tray. It is not desirable ever to touch the worms with the finger or thumb, except, perhaps, at spinning time, but even this should be avoided as much as possible. On the Continent, papier filets, or perforated paper, are used instead of nets, in four sizes, having different sized holes for the worms to creep through according to their ages. These are very cheap, being stamped by machinery, but they do not last for more than two seasons, absorbing moisture and becoming soiled. Nets, therefore, which can be washed every season are preferable, though more expensive at the outset. When there are two or more attendants, it will be well for one to go round early in the morning, and mark the trays which require changing (*i.e.*, fresh beds), with some sign agreed upon, such as a piece of paper, or card, or pill-box, on the tray; the feeder following with the fresh food, passes over that tray, till the clean net is put over the worms. In feeding, it is well to sprinkle the cut leaf at first all round the edges of the tray. Worms always follow the leaf, and as they grow larger, require more room; by feeding round the edges at first, the area for the worms is gradually and slowly increased, and more space is given. When the worms get too thick on a tray, they must be divided into two lots; to effect this, a net is spread over half the tray, and fed over. When the worms have risen, the net may be removed to a contiguous tray; but it is desirable to keep the worms of the same age near together, for reasons presently to be mentioned, the elder ones at one end of the room, the youngest at the other end, always to begin with the elder ones, and so go through to the youngest. Therefore, supposing there are six tiers or trays on each upright stand, it will be well at first to occupy two only of these with worms in their first age; those two, however, will in time occupy the whole of the six trays. If, however, these other four trays were occupied from the first with other worms, a great deal of shifting must from time to time arise of the whole of the brood, causing extra trouble to the attendant, and disturbance to the worms. Again, it is an advantage to keep them in regular order, the eldest first, and so on, always inspecting the elder worms first; for the simple reason that as each batch is a day older than the next, so in their successive changes the second batch will be, on any given day, exactly in the same condition in which the first batch was the day before. This simple rule enables the attendant to foresee regularly the coming changes, and to provide accordingly clean beds, more or less food, etc. etc., according to requirement, as he has to do one day exactly the same as he did the

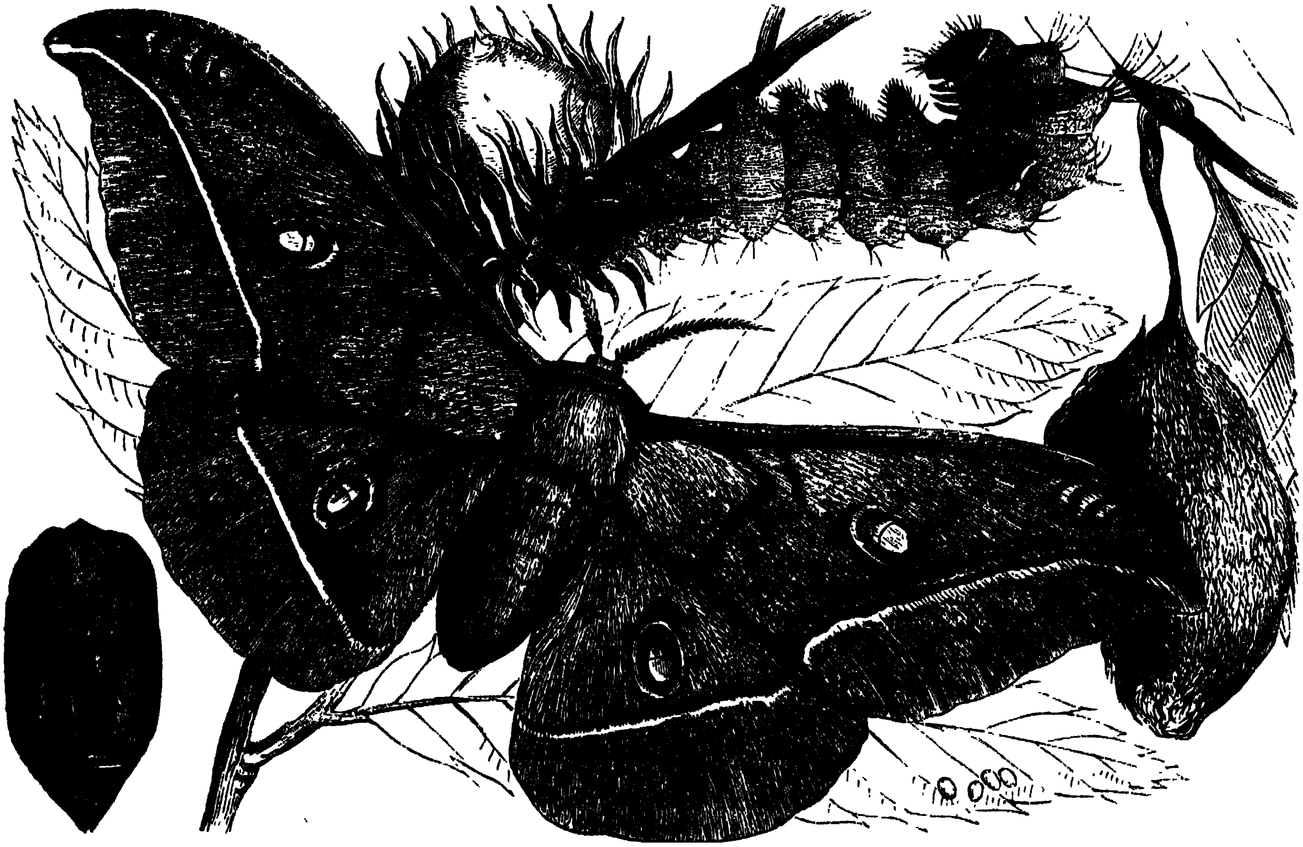
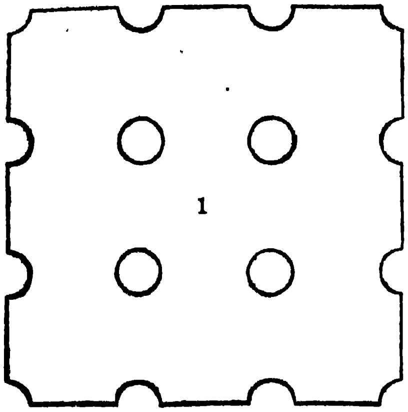


Fig. 3.—THE CATERPILLAR, COCOON, CHRYSALIS, AND MOTH OF THE BOMBYX PERNYII.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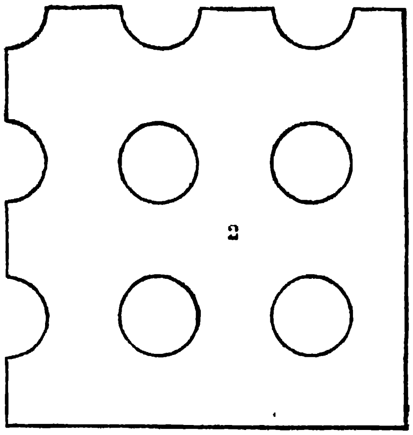
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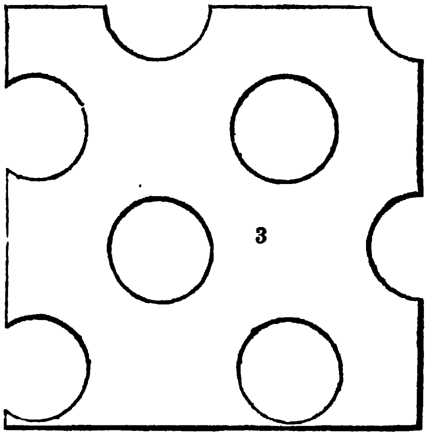
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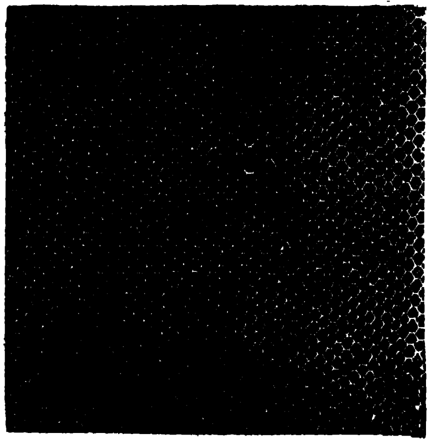
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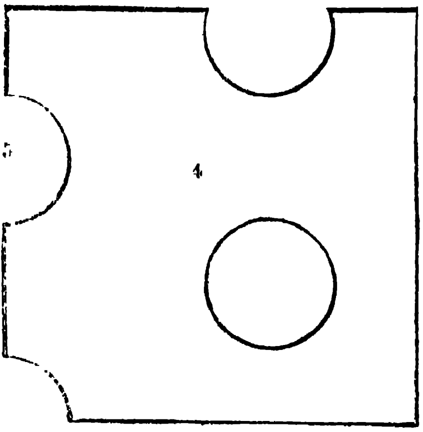
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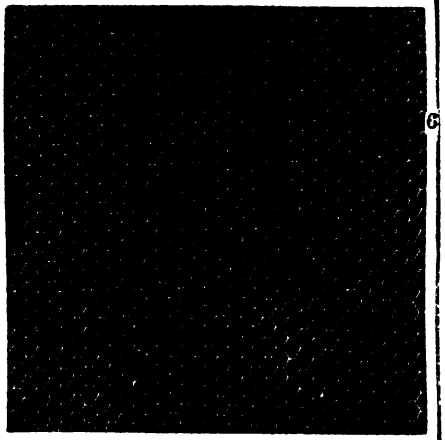
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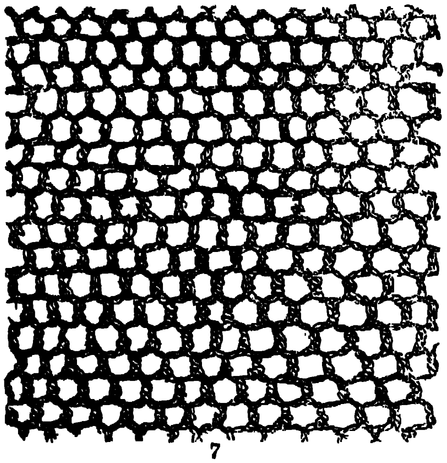
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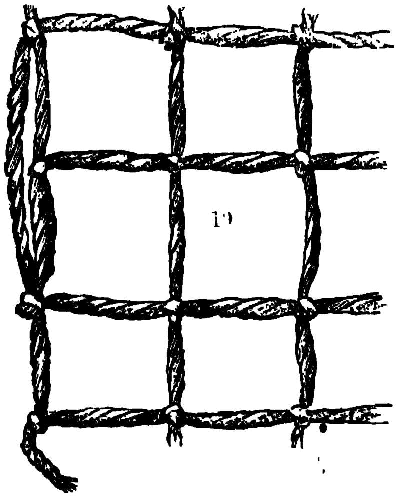
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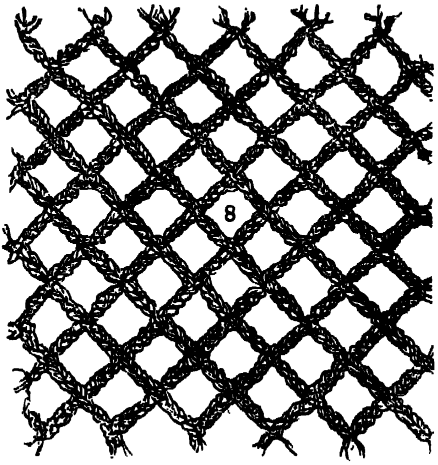
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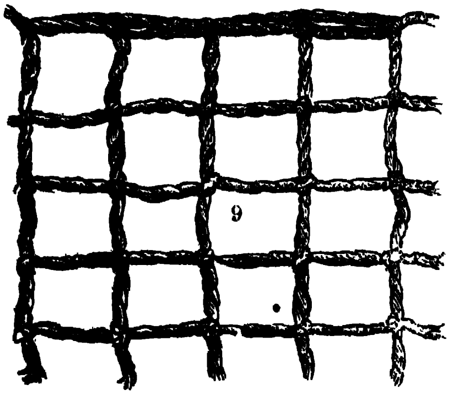
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REFS. TO NUMBERS OF FIGURES.

PAPIER FILETS,

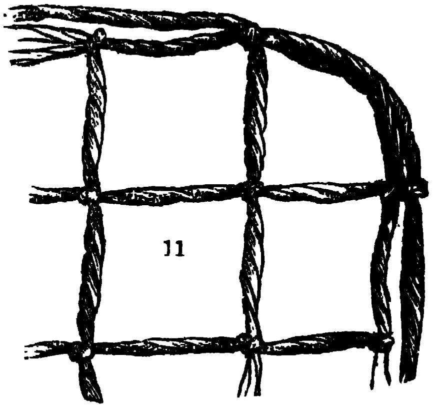
Machine made in four sizes.

1. For young worms.
2. For second and third ages.
3. For third and fourth ages.
4. For last age.

NETS.

5. Fine cap net to spread over the eggs, and for the first change of bed.
6. Larger meshed cap net for worms after first moult.
7. Machine-made nets for worms after second moult.
8. Ditto for worms after third moult.

9, 10, 11. Three different-sized mesh-nets, hand made, for worms in fourth and last stages.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day before to an older lot. In feeding, it will be found much easier to distribute the food evenly and sparingly when the hand is full of food than when only a small portion is taken up. It may be scattered in two ways, the palm being uppermost and the fingers rigid, more or less open, or manipulated by the fingers and thumb, the palm being undermost: I prefer myself the first mode. Attention must also be given to the age of the worms. After a moult the first feed should be spare, and it is also desirable to change their bed as soon as possible. After that they become very ravenous and consume a great deal of food. Again, as they approach a moult they eat less and require a light feeding, certain changes then ensue, their bodies become light coloured and somewhat transparent. They spin a secure foothold, to which they attach the hind-feet, and this done, they elevate the fore part of their bodies, their head standing up sometimes like that of a snake. In moulting, as is the case of lobsters, the skin of the head, face, legs, and body comes away, as also the lining membrane of the spiracles, or breathing apparatus, and of the intestinal canal. The creature emerges with a loose, wrinkled skin and a larger head, and seems a much bigger caterpillar than he was before. Now the result of the new face growing steadily behind the old one is to push off the latter, which, being smaller, leaves the upper portion of the new face visible. Hence, at the junction of the face with the collar or neck there is visible a greyish-looking triangular patch—in fact, the upper portion of the new face, and this, when observed, is the most certain and characteristic sign that a moult is in progress. Moulting generally occupies about forty-eight hours, but may be retarded by a cool temperature. Worms that have moulted can always be distinguished from those that have not yet done so, by the greater size of their heads. There are four moults in the worm's life; after each it greatly increases in size. There is also the emergence from the eggs, the change from the caterpillar into the chrysalis, and again the change into the moth—in all seven stages or ages, and the entrance into each new age is marked by the putting off the skin or exuvium peculiar to the former age. It is a wonderful reflection, yet true, that the tiny newly-born worm should possess the germs of six exuvia, each of them larger than the external ones, the innermost skin being the largest of all; yet so it is. It is important to recognise the impending moults which occur at regular intervals, for then the worms do not feed, and not only would food be wasted upon them, but it would inflict a positive injury; for if scattered over them at that critical period, they would be unable to rise above it, having attached their hind-feet firmly to the silken threads spun for that purpose, from which, if they are by accident released, death is the inevitable result. Moreover, their spiracles, or breathing apparatus, thirty-two in number, situated a pair on each segment just above their legs, would be unable to perform their functions (were the worms smothered by fresh food when unable to rise), respiration would be feebly performed, and disease or death ensue. It is more important to supply silkworms with an abundant supply of fresh pure air of regular temperature, avoiding draught, than with food; the latter they can go without for a period; but if deprived of the former they become unhealthy. I have often seen worms turn discoloured, and perish from being smothered while moulting, by a too liberal supply of food.

Moulting is performed as follows:—A series of contractions and extensions take place inside the old skin, by means of which the legs are withdrawn from their old envelopes, and the creature, so to speak, moves forward inside his own skin. This is evidenced on close observation, (1) by the hind-legs or claspers being observed in motion anteriorly to the old claspers; and (2) by the inner lining of the spiracle being drawn out to the extent of one-eighth of an inch in a worm moulting for the last time; these show as an interrupted white line running laterally with the spiracles. When this is observed, the active change has begun. Hitherto the worm has been motionless and passive, waiting till all was ready. Very soon, owing to pressure from behind, the animal, as it were, walking forwards within the old skin, rupture of this old skin takes place at the collar; the neck is then pushed forward, the old face still remaining on: first one pair of fore-legs and then another is protruded. The hind-legs of the old skin all the time remain firmly attached to the silken cords; but should this attachment unfortunately give way, the creature seems unable to extricate the hinder portion of its body, and the old skin turning brown, remains as a ligature preventing defæcation and respiration, and causing slow death. The worm having freed its legs, pair after pair, crawls forth, a new creature, drops its old face, and, erect on its hind-legs and claspers, waits till the new integument of the mouth, head, and legs, etc., harden; after which it starts off in search of food. The old skin, with lining membrane of spiracle and intestinal canal, remains a thin brown mass, still attached to the bed. Each moult brings with it characteristic changes in appearance, so that the age of the worm is well known by the experienced feeder. When first hatched the worms are such tiny black or brown specks, that they are hardly visible to the naked eye when resting on the cut leaf. Their presence can, however, be easily discovered if the attendant breathe upon the food. This is distasteful to the worms, and they immediately move their heads and bodies from side to side. This is a useful method, when looking over the litter after the worms have been cleared, to ascertain if there are many *retardaires*. The following lines show the sizes of the worm—(*a*) When just hatched; 1, 2, 3, 4, at the close of its different ages; 5 the length of a full-grown worm just before spinning.

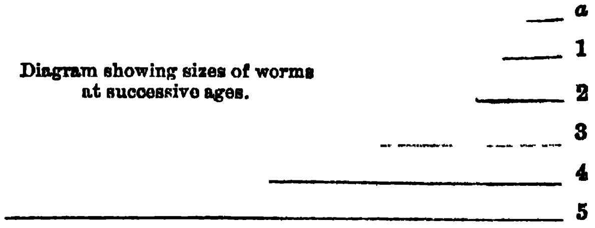
Diagram showing sizes of worms at successive ages.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

III.—INTERNATIONAL MUSEUMS.

Construction, Arrangement, etc.—At the International Exhibitions of 1851 and 1862, the exhibits of each country were arranged in separate "courts," the various objects being grouped in these under classes and sub-classes, according to a recognised scheme of classification. Though well adapted to meet the national pride of every country, and the natural feeling for pomp and display, such an arrangement proved eminently inconvenient to all earnest students who wished to compare the natural products or manufactured articles of one country with those of another—having to toil from one point of the building to another far distant, often to waste valuable time in searching out a particular object if it happened to be in a small collection, and always with the drawback of having to carry in the mind's eye the quality, style, etc., of the sample with which comparison was to be made. Under such an arrangement of exhibits it became a matter of necessity to go over the collection of every country, and make a tour of every court, inspecting objects in which one took no interest, to make sure objects sought for had not been overlooked, so that in the case of a provincial or foreign visitor making but a limited stay at the seat of an exhibition, it became impossible to make a complete and satisfactory examination of any class of objects in which he took a studious or commercial interest. Beyond this, the distribution of space, to meet the requirements of great and small countries, the exigencies arising from the exhibits of some countries falling short and others exceeding the space calculated for, leads to the ground-plan of exhibitions so arranged becoming unmethodical, unsystematic, and difficult to comprehend or follow. The experience thus gained made it evident that a simpler system for distributing the exhibits of international contributors was a necessity if such collections were to serve the purpose of study, as well as those of mere display. Consequently, in the official programme for the Exhibition of 1871, we found it announced that "*The arrangement of the objects will be according to classes, and not, as in former International Exhibitions, according to nationalities.*" Unfortunately, this palpable move in the right direction was never properly carried out, except in the picture-galleries, departments for machinery in motion, and new scientific inventions, nor were the new galleries adapted for carrying out the proposed arrangement, as the rooms devoted to educational appliances and porcelain, etc., were only large enough to hold the British exhibits, and would not have been large enough for that purpose had they been fully represented. Thus the Educational Department very imperfectly represented the appliances in use in Great Britain for teaching, especially in the section for Science and Art, many well-known firms being entirely unrepresented, while others only exhibited just enough to give their names a place in the catalogue. This is to be regretted, as a complete collection of the educational appliances of all nations arranged, as proposed, in one class, would have formed a most valuable and instructive collection; whereas the foreign educational collections had to be hunted out in various parts of the building, though the official catalogue led one to look for them collected together in one gallery—an opportunity lost, which, according to the arrangements laid down by Her Majesty's Commissioners for the annual exhibitions, will not present itself again for ten years to come.

If practical experience has taught us that *the arrangements* in past English exhibitions have proved defective, on the other hand, we have learnt a lesson as to what proved eminently effective and beautiful in the constructive details of such buildings; for who that visited the Great Exhibition of 1851 can ever forget Paxton's Crystal hive, suggesting a design begotten in a dream of fairy-land; a palace framed of spider's web, the interlacings filled with entangled films of dew; or the overpowering feeling a glance down the endless vista of that magnificent nave never failed to produce, a vista dotted with many a trophy of science, art, and manufactures; extending apparently to infinity, typical of the broad road that lies before inquiring man—a road that must be followed slowly, patiently, and with never-ending toil, but toil that never depresses, for the way is bathed in a golden flood of heaven-born light, and the heart will be lightened by a foregone conviction, that, however small a portion of that road can be traversed, there must be a proportionate gain, for it leadeth to an increase of knowledge;—who can have traversed that crystal vault without bearing away an undying recollection of *The Amazon*, *The Mourners*, *The Stuttgardt Horses*, *The Greek Slave*, the glorious roll of the huge organs, or the harmonious blending of colour, form, and light? If ever there was an embodiment of the poetry of architecture, it was in Paxton's Hyde Park edifice. The building of 1862 was wanting in grandeur, and was deficient in light, and the sculptures grouped in the nave were mostly hemmed in with incongruous objects. In the galleries erected for the proposed annual exhibitions, the space seems to be too much cut up to allow of the rule for the exhibitors of all nations of a given class of objects to be arranged in one unbroken series, so (as in 1871) there must be a return to the system of national courts and annexes. Provision for the pageantry of opening ceremonials, etc., connected with the exhibitions is utterly unprovided, though it was a natural conclusion that the Albert Hall—the finest building since the days of the Roman Coliseum for holding large assemblages of spectators—so closely connected with the galleries, would have been employed on such occasions. The Horticultural Society's conservatory proved quite inadequate as to space for the purpose of the opening ceremony of 1871, and the procession through the picture-galleries utterly unimposing as part of a state ceremonial, for the eye had no opportunity of taking in more than infinitesimal portions at a time, to say nothing of the lopsided, unsymmetrical aspect produced, through only one side of the rooms being devoted to the passage of the official walk round. The absence of music during this progress was another serious shortcoming. In the construction of a building to meet the requirements of any future International Exhibition on the scale of the English and French displays between 1851 and 1867, it will be obvious that provision should be made for a grand central hall fully lighted from above, wherein could be grouped the sculptures, the trophies of science, manufactures, and characteristic products of the various countries, embedded in a background of natural foliage, surmounted by the banners and armorial escutcheons of the nations of the world, to reproduce the *coup d'œil* that proved so eminently effective under Paxton's glorious nave, to which the harmonious colouring of Owen Jones added not a little. In a hall of such proportions there would be ample space for the proper display of the pomp and pageantry of state ceremonials, with their attendant processions, and for the suitable distribution of powerful musical instruments, such as organs, etc., over so vast an area, to provide against a repetition of the palpable shortcoming of 1871; for a procession without the accompaniment of stately march music always proves spiritless and tedious, and appears as incongruous as playing "Hamlet," and dispensing with the part of the *Prince of Denmark*. It is also obvious that the general plan of the building should adapt itself to a scheme of arrangement that should be simple of comprehension, and allow of objects of a similar character being brought together for comparison under CLASSES, without separating individual contributions from THE COUNTRY to which they pertain—an arrangement such that a visitor could, at will, examine a class of objects contributed by all the exhibiting nations, or only the collective contributions of a single country to a given class, and that within the range of one gallery, and without sacrificing national prejudices. Such a problem I attempted to solve in 1862, while experiencing the inconvenience of the higgledy-piggledy distribution of scientific objects in that year's Exhibition, and discussed in the first of a series of critical articles on "The Photographic Apparatus and Appliances at the International Exhibition," in *The British Journal of Photography*, Vol. IX., page 331, and I believe my scheme would be found to meet all the requirements. On each side of the central hall as many galleries as there are classes should be symmetrically arranged, extending, like parallel streets, the entire length of the building, but intersected at convenient intervals by passages, to facilitate easy communication between one part of the building and another—a matter of the utmost importance.

Each *Class Gallery* should be subdivided according to *nationalities*, and the space allotted to each nation should be just sufficient to contain its exhibits belonging to that particular class. So that each *Class Gallery* would be quite independent of those adjoining, and be arranged without reference to the space or exact locality any nation's exhibits might occupy in other class-galleries; the idea of forming national Courts for exhibits of varied character, such as we saw in the French Annexe in 1871, being ignored. This system of arrangement will be made clear by the annexed diagram (Fig. 1).

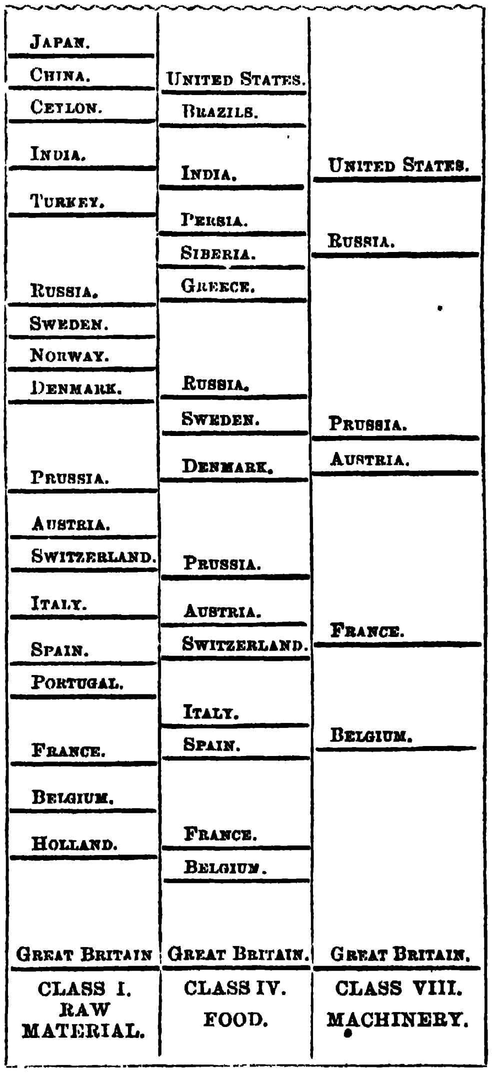

Fig. 1.

TECHNICAL DRAWING.—LIII.

GOTHIC STONEWORK.

POINTED ARCHES — TRANSITION DOORWAY — ROLL AND FILLET.

It has already been said that pointed arches were introduced during the latter part of the twelfth century. Before its close they were used in many varieties of form, from the barely-pointed or low "drop" arch to the acute lancet. Fig. 468 is a Transition doorway in the north wall of the ruins of St. John's Priory, Chester, in which will be seen not only the pointed arch, but the square abacus, to the now shaftless capitals.

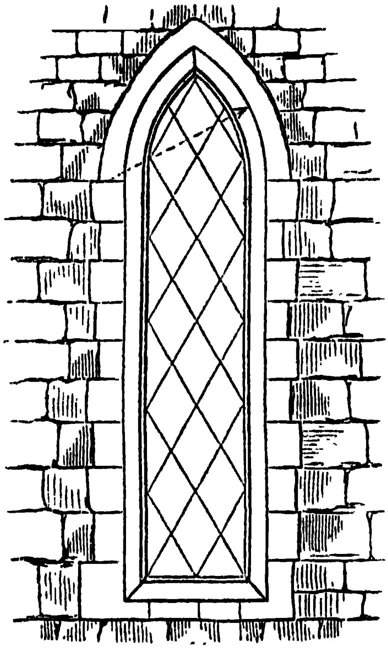
Fig. 473.

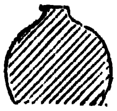
Fig. 471.

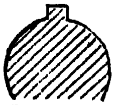
Fig. 470.

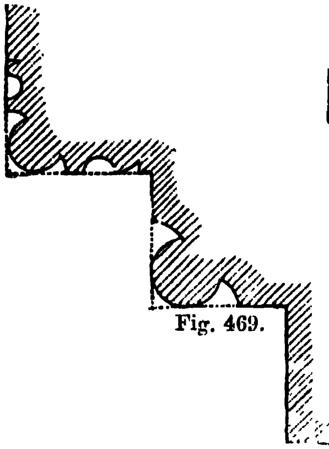
Fig. 469.

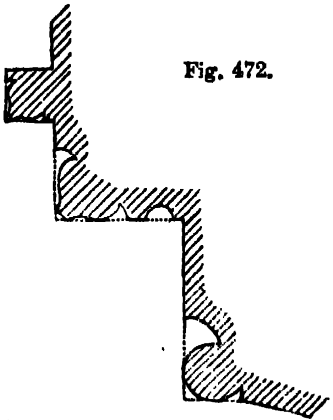
Fig. 472.

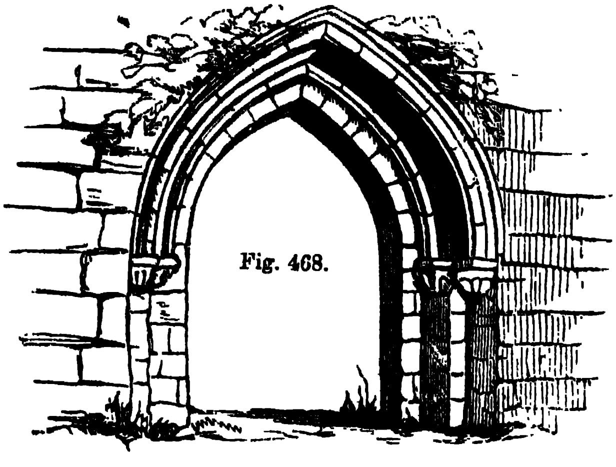
Fig. 468.

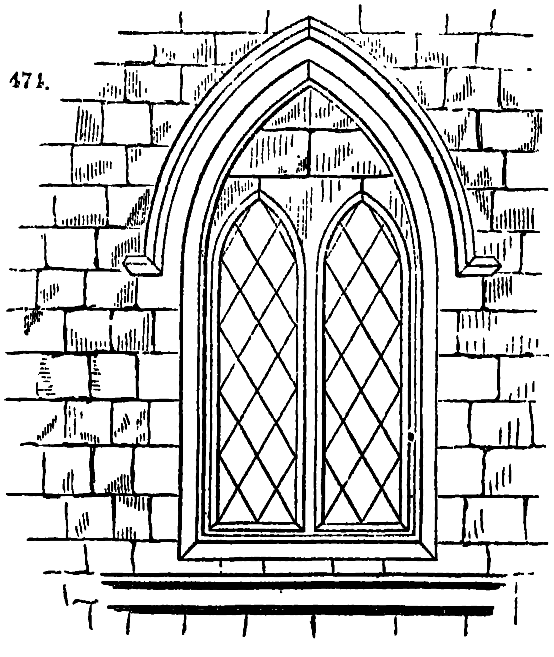
Fig. 474.

Fig. 469 is an enlarged section of the arch-moulding, from which it will be seen that the regular character of the several orders was still retained; but the mouldings cut upon them became more varied and numerous, and several new forms were introduced. In this figure the first order is plain, with the square edge; the second has the simple Norman edge-roll; but the third is of a more complicated character. The edge-roll has *two* hollows on each side, and the second has the sharp indented line carried round it.

The most important form, however, introduced during this period of transition was the "roll and fillet," a moulding which continued to hold a leading place in the combinations of all the succeeding styles. It may be described as a narrow band or fillet, set flat upon the face of the common cylindrical roll or bowtell. In the earlier examples it is mostly set square upon the round member, as in Fig. 470; but it is often found with the joining edges rounded off so that the fillet merges gradually into the roll, as shown in Fig. 471.

An example of the manner of placing this moulding in the Transition style is given in Fig. 472.

THE EARLY ENGLISH PERIOD.

This style, the first of the pointed arches, may, in general terms, be called the thirteenth century style, extending, on the whole, as it did from about 1180 to about 1309, including part of the reigns of Henry II., Richard I., John, Henry III., and Edward I.

The architecture of this period is exceedingly beautiful and chaste; simple and elegant in design—excellent and delicate in execution; equally applicable to the modest village church and the noble abbey and cathedral; remarkable in the one for its unobtrusive simplicity, and in the other for its solemn and majestic grandeur.

"Nothing," says the Rev. J. N. Hutchinson, "could be more striking than the change from Norman to Early English. The two styles were the complete opposites of each other. The round arch was replaced by the pointed, often by the acute lancet; the massive piers by graceful clustered shafts; the grotesque and rudely-sculptured capitals by foliage of the most exquisite character; and the heavy cylindrical mouldings by bands of deeply undercut members."

The most generally used arches at this period were the acutely pointed, either lancet or equilateral. As a rule, the arches are comparatively more acutely pointed in cathedrals and the larger churches, whilst the obtuse angles are most frequently used in the smaller churches.

The semi-circular arch had not entirely gone out of vogue, and at Whitby Abbey, and in other examples, we find it combined with the pointed, two or more of the latter being sometimes included under one of the former. There are also examples in which the semi-circular form is used alone. The soffits of the arches were, in the larger examples, richly moulded with a series of rolls and hollows in a manner which will be more explicitly referred to further on, but in buildings of a less magnificent character they were merely recessed in orders, the edges being simply chamfered.

The dripstones over doors or single windows follow the form of the arch; but where the windows consist of several separate lights—that is, where each window is made up of several others placed close together—the dripstone forms a sort of gathering arch over all. This seems to have led to the introduction of tracery, the progress of which will be illustrated presently.

The doorways of this period are very frequently furnished with nook-shafts, which are for the most part detached from the walls, except at the capitals and bases. The more simple doorways have only one shaft on either side, supporting an archivolt of a few bold mouldings. More elaborate specimens have two or more shafts on either side, and a greater number of mouldings in the arch.

The jamb is recessed in order to receive the shafts, and the spaces between the mouldings or their hollows are often filled up with an ornament called "the dog-tooth"—a leading type of the style—or a running pattern of foliage. A beautiful specimen of such a doorway may be seen in the ruins of Valle Crucis Abbey, near Llangollen, North Wales, where there is also a fine three-light window of a very large size, three lancet-headed lights being gathered under one dripstone. The doorways of the larger structures are mostly divided into two arched apertures by a simple or clustered shaft, which is often of polished marble with richly-carved or moulded capital. The arches are also foiled or foliated, the spandril between them being perforated in circles, trefoils, etc., and sometimes filled with foliage or groups of sculpture.

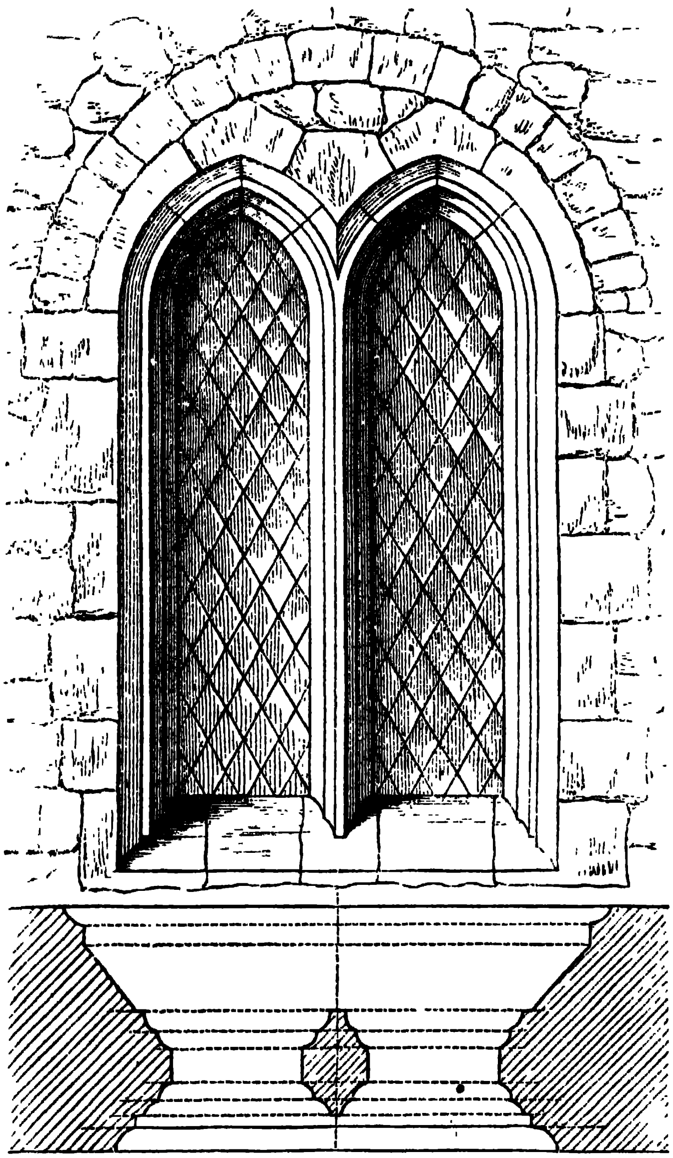

Fig. 475.—TWO-LIGHT WINDOW FROM THE NORTH AISLE OF STOKE POGIS CHURCH, BUCKS.

The doors themselves are either plain or covered with iron scroll-work, and sometimes with hinges, which are often of a very ornamental character, although at other times nearly plain. An excellent specimen of such iron-work exists on the doors of a vestment-closet in one of the small chapels in Chester Cathedral, and in the Chapter-house, York Minster. Very fine ornamental hinges, covering almost the whole door, may be seen at Eaton Bray Church, Bedfordshire, at St. Mary's, Norwich, etc.

EARLY ENGLISH WINDOWS.

One of the most interesting branches of the study of Gothic architecture is that connected with the history and progress of windows, marking as it does the gradual development from the most simple forms to the culmination in the grand tracery which characterises the windows of the next period; the increase of size and falling off in the graceful forms in the subsequent style; the flattening of the arch and consequent diminution of the tracery; and, finally, the decay of the whole system.

The windows of the style now under our consideration are, for the most part, long and narrow, with acutely-pointed heads (Fig. 473). The earliest and simplest form is that of a long, narrow, single light with arched head, and without moulding of any kind, either internally or externally, the exterior angle being merely chamfered, and the interior widely splayed.* Such windows were sometimes without any weather-moulding, but occasionally a string-course was carried from one window to another at a level with the springing of the head, and then lifted over it, adopting its form, and then carried on to the next aperture. As the period advanced, these windows were placed near each other, in groups of two, three, five, or more, the first being usually found in the sides of churches, and the latter at the east end, except in very large buildings, where it is found in all positions. It has been mentioned that where windows of more than one light were employed, it was a common practice to include them under one dripstone, the head of which was left plain. Such a window is shown in Fig. 474, and from this it will be seen how the introduction of tracery became necessary for the beauty and lightness of the form.

The next study is a view of a two-light window from the north aisle of Stoke Pogis Church, Bucks, drawn to scale of ½ inch to the foot (Fig. 475).

In this example the plan is to be drawn first, and the jambs and mullions should then be projected by perpendiculars drawn from the plan. The arches are rather lower than they would be if the distance from the springing to the apex were the same as the width of the lights. The centres therefore fall between the springings.

In this illustration it will be seen that the dressings of the window are tooled, whilst the wall is of coursed rubble, strengthened over the window by a relieving arch.

In drawing the various examples afforded by our present series of illustrations, care should be taken to render the work as sharp and clear as possible. The stone-work and the shading which it exhibits will be rendered best by a steel pen charged with Indian ink.

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* *Chamfer, Splay.*—Both these terms mean cutting away the edge of anything which was originally right-angled, so that instead of an edge, a slanting surface may be presented. A chamfer differs from a splay in being smaller, and usually cutting off equal portions from either side. It will be understood that by splaying the inner sides of narrow windows, the rays of light were permitted to spread, and thus the interior was better lighted.

NOTABLE INVENTIONS AND INVENTORS.

XXIII.—THE MARQUIS OF WORCESTER AND HIS "CENTURY OF INVENTIONS" (*continued*).

BY JOHN TIMBS.

THE "Century of Inventions," by the Marquis of Worcester, has been described as "an amazing piece of folly" by a few shallow persons. It contains the description of one hundred inventions, of which those relating to the Water-commanding Engine have been described. Mr. Partington, in his edition of the "Century" published from the original MSS. in 1825, in an able series of notes, shows the practicability of the major part of the hundred inventions, and the application of many of them, under other names, to useful purposes. We quote the list of inventions, with such portions of certain of the notes as the space at our command will allow.

1. *Seals*, upon any of which a man may keep accounts of receipts and disbursements, from one farthing to one hundred millions, punctually showing each pound, shilling, penny, or farthing. By these seals, likewise, any letter, though written but in English, may be read and understood in eight different languages. The principle is, "A frame similar to those in which seals are generally mounted, and movable circles made to slide within each other on one common centre. If three are employed, they should be engraved with the numerals, the alphabet; and, if intended for secret writing, the third circle may be furnished with arbitrary signs. Those, by means of a key, of which both the corresponding parties must possess a duplicate, may be combined to form the day of the week, month, year, etc."

2. *Seals, private and particular to each owner*, the deciphering depending on the smallest variation of the key.

3. *A one-line cipher.*

4. *Reduced to a point.*

5. *Varied significantly to all the 24 letters.*

6. *A mute and perfect discourse by colours.* A telegraph which must have nearly resembled that in use at the present period.

7. *Telegraph by night*, rockets or reflecting lamps being substituted for painted boards.

8. *To level and shoot cannons by night as well as by day*, without a platform or measures taken by day.

9. *A ship-destroying engine*, portable, to be fastened inside the greatest ship, and at any appointed day or minute, day or night, it will sink that ship; it being merely necessary to connect a gun-lock with a common bomb-shell, fitted in the usual manner, and a small clock attached, which will at any given time discharge the lock, and cause the shell to explode.

10. *How to be fastened from aloof and under water.* This engine resembles Fulton's torpedo.

11. *How to prevent and safeguard any ship by day or night.* "A strong net is to be kept at the required distance from the vessel by floating buoys; upon the upper extremity of each buoy is fixed a bell, which, by its ringing on a certain night, discovers the approach of any hydrostatic vessel; and should the weather be stormy, the attempt must end in the destruction of the submarine voyagers."

12. *An unsinkable ship.* A way to make a ship not possible to be sunk, though shot at a hundred times between wind and water by cannon; and should she lose a whole plank, yet, in half an hour's time, she could be made as fit to sail as before. The hull of the vessel to be composed of a number of small divisions, when it will scarcely be possible to sink it, especially if a sheet well prepared with oakum be drawn under the vessel in the event of a fracture, as the pressure of the water on the vessel's surface will force the canvas into the chasm; a method long adopted in the navy.

13. *False destroying decks*, to kill and take prisoners boarding the ship, without blowing the real decks up.

14. *Multiplied strength in little room.* How to bring a force to weigh up an anchor, or to do any forcible exploit in the narrowest or lowest room in any ship, where few hands shall do the work of many—by an endless screw or worm, to remain stationary at any point.

15. *A boat driving against wind and tide*, which, though directly opposite, shall force the ship or boat against itself. This is done by a globular windmill erected in the centre of a ship, for turning two wheels or paddles placed on the bows, which would impel the vessel forward in any direction that might be required.

16. *A sea-castle or fortification, cannon-proof*, to contain 1,000 men, yet suitable to defend a passage, or, in an hour's time, to divide itself into three ships. Bomb-proof batteries were used by the Spaniards in their attack on Gibraltar, in 1782; they resisted the shot and shell, until General Elliot, by red-hot balls, burnt through the outer layers into the hold used as a depository for powder, and thus destroyed this immense flotilla.

17. *Floating gardens upon the Thames*, with trees, flowers, banqueting-houses, stews for fishes, delicate bathing-places, music made by mills, etc. The floating pleasure bath, moored near Westminster Bridge, was supported by empty casks; and, says Mr. Partington, "this plan, if assisted by mooring-chains, may be applied to gardens of any reasonable extent, even in the broadest and most rapid extent." The Mexicans formed their floats by first plaiting or twisting willows, with roots of marsh plants, and upon this foundation they placed mud and dirt drawn from the bed of the lakes.

18. *An hour-glass fountain*, of which, when the upper division is exhaused, the lower may be elevated by a crank or lever, the fluid passing through the centre of its axis. The Marquis states that the water may produce snow, ice, thunder, and the singing of birds, but how is not explained.

19. *A coach-saving engine, within a coach*, whereby a child may stop it, by unloosing the coachman and horses.

20. *A balance water-work*, to bring up water by its weight within the buckets, which counterpoise and empty themselves into one another; the uppermost yielding its water, at the same time the lowermost taketh it in, though it be a hundred fathoms high.

21. *A bucket fountain*, to raise water with two buckets only, without any other force than its own motion.

22. *An ebbing and flowing river*, to work with a child's force. Bogaerts' canal-lock effects this object, in which a small portion of water assists in displacing several tons of the same, and there is no doubt but *a child's force* would raise double the quantity of water described by the Marquis. In the model a weight of seven pounds was made to raise 10 cwt. of water more than four feet in a few seconds.

23. *An ebbing and flowing castle clock*, showing the hours, minutes, and seconds, and the motions of the heavens, and counter-libration of the earth, according to Copernicus. The Marquis's astronomical machine must be provided with two barrels, each with sufficient maintaining power for the correct performance of the whole. In addition to the supporting line, each barrel has a revolving pulley, with chains passing over their axes, and attached to wood floats, alternately raised or depressed by ebbing and flowing of the tide, and thus winding up the clock.

24. *A self-increasing spring*, so as to shoot bombasses and bullets of a hundred pounds weight a steeple height, "admirable for fireworks and astonishing of besieged cities." Upon this, Mr. Partington notes: "The strength of a compound spring formed of two metals may, by the application of heat, be increased to any given power." *Rationale*: Iron possessing an expansive power $\frac{1}{85}$, and brass being only $\frac{1}{60}$, the weaker metal will be bent by that whose power of expansion is greater, and the impulse of the spring increased in equal ratio.

25. *A double drawing engine for weights.* "How to make a weight that cannot take up a hundred pound, and yet shall take up two hundred pounds, and at the self-same distance from the centre; and so, proportionally, to millions of pounds." Mr. Partington considers this paradoxical and unscientific, and regards it as one of the *marvels* which brought the whole "Century" into disrepute.

26. *To and fro lever.* To raise a weight so well and as forcibly with the drawing back of the lever as with the thrusting it forwards; and by that means to lose no time in motion or strength. This the Marquis saw in the Arsenal at Venice. It is the mere application of a crank.

27. *A most easy level draught.* A weight attached to an ordinary crane.

28. *A portable bridge.* The apparatus, to be attached to the banks of a river, consists of two ropes or wires, tightened by a winch, on which slide pulleys connected with a large floating tank or wagon. The communication is effected by means of two cords between the opposite banks of the river.

29. *A movable fortification,* "to contain 500 fighting men, yet, in six hours' time, to be set up and made cannon-proof upon the side of a river, with cannon mounted upon it." This Mr. Partington does not attempt to elucidate.

30. *A bulwark* to be raised in one night, twenty or thirty feet high, cannon-proof, and cannon mounted upon it; with men to overlook, command, and batter a town; and with but four pieces to discharge 200 bullets each hour. Upon this Mr. Partington notes the effects of highly elastic vapour propelling leaden bullets, by Perkins's "Steam Gun;" and these engines can discharge nearly 200 bullets in one-sixth part of the time described by the Marquis of Worcester in the above article.

31. *Blind* for approaching a castle and town wall and ditch. A strong wheel carriage and heavy iron tower, hung round with sand-bags; the tower to be moved by handles fixed to the axles of the wheels, to be turned at pleasure by those within the walls. Nearly similar machines are described by Vitruvius.

32. *A universal character,* "methodical and easy to be written, yet intelligible in any language; so that if an Englishman write it in English, a Frenchman, Italian, Spaniard, Irish or Welshman, being scholars, yea, Grecian or Hebridist, shall as perfectly understand it in their own tongue, as if they were English, distinguishing the verbs from the nouns, the numbers, tenses, and cases, as properly expressed in their own language as it was written in English." Mr. Partington's note extends to six pages, sketching the various contrivers of a numerical character, and quoting memoirs of Francis Bacon, Descartes, Becker, Dalgarno, Frisichius, Kircher, and Bernier. But the most remarkable work is that of Bishop Wilkins, whose real character is supposed to strongly resemble that of his contemporary, the Marquis of Worcester. The bishop explains the signs which are to be used to denote all the principal ideas, the relative attributes being designated by small strokes added at right, acute, or obtuse angles, to the right or left, etc. He admits chief ideas, forty in number, under which he ranges all the others by a series of categories. Leibnitz's "Universal Language" is generally known: he considered his characteristic as the art of inventing or judging; he was convinced that an alphabet might be formed, and of this alphabet such words as would afford language capable of giving mathematical precision to all the sciences.

33. *A needle alphabet.* (See 75.)

34. *A knotted string alphabet.* "This very ingenious mode of *secret writing,*" says Partington, "is the most simple of any suggested by our author. A silk string of considerable length furnishes the persons corresponding with a key, or graduated gauge, by means of which the writing will be rendered intelligible. Having procured a duplicate or corresponding gauge, it may then be commenced, $\frac{1}{16}$ of an inch being allowed for the first letter, $\frac{1}{4}$ for the second, $\frac{3}{8}$ for the third, and so on, in equal proportions, through the whole alphabet."

35. *A fringe alphabet.* "The principle of this and the four following articles," says Partington, "is the same as the preceding, with this difference, that in the first, the letters or words are formed by knotting the fringe, to which the gauge is afterwards applied; in the second and most durable way, the beads are set to the required distance; by the third, the gloves are pierced or pricked in rows, according to the divisions on the gauge; and by the fourth and fifth, the rows of parallel holes in a sieve or lantern are stopped at the required distances, and the gauge applied as before."

36. *A bracelet alphabet.*

37. *A pinked glove alphabet.*

38. *A sieve alphabet.*

39. *A lantern alphabet.*

40. *An alphabet by the smell.* Pegs of sandal, cedar, and rosewood may be so varied, that a person writing in the dark will, by the smell, readily distinguish the formation of words and sentences.

41. *An alphabet by the taste.* Immerse an equal number of the pegs or beads in weak solutions of alum, aloes, common salt, or any other liquid whose taste is sufficiently pungent or aromatic to be distinguished when dry, on applying the tongue to them for that purpose.

42. *Alphabet by the touch.* By these three senses, as perfectly, distinctly, and unconfusedly, yea, as readily as by the sight. The object (says Partington) may be readily attained by the use of raised movable types and the heavy pressure of an iron pen or mallet. A mode of corresponding by the touch has been suggested by M. Haüy, and by this means the blind have been fully instructed.

43. *How to vary each of these,* so that ten thousand may know them, and yet keep the understanding part from any but their correspondent. This may be effected by changing the order of their arrangement, which can only be ascertained by a previous examination of a key chosen for that purpose.

44. *A key pistol.* To make a key of a chamber door, which to your sight hath its wards and rose-pipe but paper thick, and yet at pleasure, in a minute of an hour, shall become a perfect pistol, capable to shoot through a breast-plate, commonly of carabine-proof, with prime, powder, and fire-lock, undiscoverable in a stranger's hand. The *pipe* must, in this case, be formed like the sliding tubes of a telescope; that next the wards being furnished with a screw at the inner end, capable of holding the whole of them together. A small quantity of detonating powder being first placed within, the pipe may be readily discharged by tightening of the screw.

45. *A most conceited tinder-box.* How to light a fire and a candle, at what hour of the night one awaketh, without rising or putting one's hand out of bed; and the same thing to be a serviceable pistol at pleasure. The pistol tinder-box (says Partington) may be readily made to perform the whole of what is here described. A bell-rope attached to the trigger will suffice to elicit fire, which, communicating with a quick-match or fusee, will quickly ignite and produce the required light. If the fire is previously prepared with wood or other combustible material, and inflammable spirits sprinkled over it, the slightest spark will throw the whole into a blaze. Of the latter qualification mention is made by the noble author, a piston barrel may easily be secreted under the tinder. The inflammable air-lamp, contrived by Volta, possesses similar properties; a stream of hydrogen gas being inflamed by the spark of an electrophorus. For information on this subject, see Brande's "Manual of Chemistry," Vol. I., p. 240.

46. *An artificial bird* may be made to fly, which way and as long as one pleaseth, by or against the wind, chirping or hovering. In the year 1810, two birds were exhibited at Merlin's Museum; they performed all the evolutions described by the Marquis of Worcester.

47. *An hour water-ball* may be made of any metal, which, thrown into the water, presently rises from the bottom, and shows by superficies of the water, the hour of the day or night, just to the minute it showeth of each quarter of an hour. "A metal ball," says Partington, "graduated on the surface, in the same manner as the index stem to an hydrometer, with a balance to preserve its equilibrium, must first be exhausted of air, when the water may be made to enter by a small aperture, and it will gradually sink till the vessel is filled; this, if the ball is about twelve inches in diameter, and the aperture of a proportionate size, will not take place in less than twelve hours."

48. "*A screwed ascent of stairs,* with fit landing-places to the bed-chambers of each storey, with back stairs to the *nod* of it, convenient for servants to pass up and down to the inward rooms of them, unseen and private." It is most probable (says Partington) that the Marquis here alludes to the geometrical staircase now in such general use, with the addition of a small flight of stairs in the centre, in lieu of the common hand-rail, which, being surrounded by a partition of boards, would serve as a private communication with the upper storeys; sufficient space being left between the ceiling and upper side of the principal staircase to admit of a passage to the inner rooms.

49. *A tobacco-tongs engine,* whereby a man may get over a wall, or get up again, being come down, finding the coast proveth insecure for him. By tobacco tongs is supposed to be meant a combination of levers, jointed together; when by distending the lowest arms horizontally it may be made to go in the smallest compass; while by closing them the machine will be elevated. A *fire-escape* has been constructed upon this principle.

50. *A pocket ladder,* fastened a hundred feet high to get up by from the ground. This consists of light brass tubes, each having a socket to receive the end of the preceding joint, to be raised to any given height.

51. *A rule of gradation,* which, with ease and method, reduceth all things to a private correspondence, most useful for secret intelligence. (See article 5.)

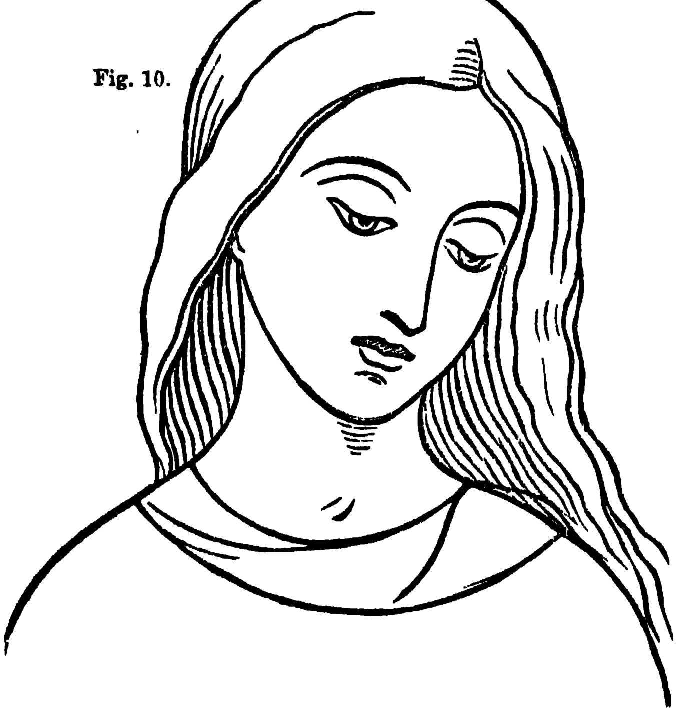
PRACTICAL APPLICATION OF THE FINE ARTS.—VI.

THE ART OF GLASS PAINTING.

By P. H. Delamotte, Professor of Drawing, King's College, London.

In Figs. 10 and 11 we have progressive examples of the principles that we have expounded before. These are two stages of the same work. Note, to begin with, that we give a face in which we intend to convey the sweetness and expression of the old painters, combined with the improved drawing of the nineteenth century. This is perhaps as important a lesson as we can convey to the student of the present day—more valuable by far than any mere directions as to the mechanical execution of the work, because it refers to the cultivation of the taste, the education of the mind, and the elevation of the aim, rather than the instruction of the hand or the adaptation of the means. There is good in the old and in the new. The ancient aimed at elevation of thought-feeling. In representing a Madonna, he would try to suggest notions of purity, of love, of feminine delicacy, and the like; he would wish his picture (or window) should be a sermon when no priest was at hand to preach, a book to those who knew nothing of letters. At the same time he was ignorant of anatomy, he had but little knowledge of the nude figures; the artist was a monk, not a spectator of the gymnastics of Greek athletes. His knowledge of foreshortening was empirical, and atmospheric effects he had no means of representing. Consequently, his drawing was extremely bad in many good pictures, and foreground and background were in inextricable confusion. Knowing but very little on these subjects, but feeling strongly about others, in some respects he was excellent, in others he is far excelled by the moderns.

Fig. 10.



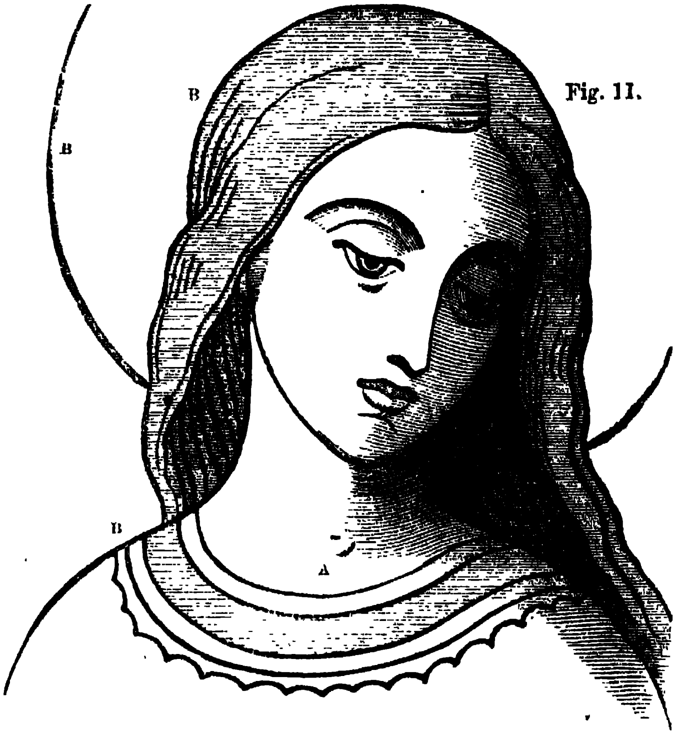


Fig. 11.

Fig. 11 represents the first stage of a somewhat elaborate portion of a picture. Naturally more labour and care will be expended upon the heads in a picture than upon any other portion. We have already spoken of carefulness of design; but unless there is very careful elaboration of the design, the latter will be liable to be spoilt in the manipulation. The glass upon which heads are executed is usually smoother, and more free from air-bubbles, than that intended for draperies and other coarser portions. There is a certain latitude, too, of tone; for the heads of men a deeper colour will naturally be employed than for delicate female heads. It should be remembered in the choice of glass, that the colour of the material should not exceed that of the lightest portion of the design. The glass may then be placed on the paper on which the charcoal drawing has been made, and with a long sable brush, No. 2 (Vol. II., p. 304), the whole of the outline of such a design as Fig. 11 may be traced in with the enamel mixed with water. This is one of the advantages of the glass that the design may be traced through, though it will be found necessary afterwards to suspend the glass on a frame, so that it may be clearly seen if any parts are omitted, and to correct any mistakes or harshness of outline that might result from the former process. We all know what is the appearance of a child's so-called transparent-slate, and the harsh drawing that is drawn thereon. This, of course, is to be avoided; but at the same time the transparency can be made available for getting in the larger and coarser outlines. When the result is satisfactory the whole may be left to dry, and may even be sent to the oven to be burnt in. It is, however, better to avoid more burnings than are absolutely necessary, and the most satisfactory glass generally is that which has been burnt but once.

The first outline being fixed, we go on to the additional shading in Fig. 11. Down the right-hand side of the face the slightly curved lines marked A are intended to represent a smudge, or stipple shading, which is laid on with one of the larger camel's-hair brushes (No. 1), and then dabbed with the point of a hog's-hair tool (No. 5). The deeper outlines will be a guide for a good portion of this work, but some will have to be shaded off. This latter process is best accomplished by carrying the shade a little beyond the place at which it is intended to stop, and then when it is dry rubbing off a portion with No. 3 or 4. It will be observed that the shade spreads not only on the face and neck, but also on a portion of the hair—that part, namely, nearest the face and neck. The straight horizontal lines, B, across the hair and top of the dress are intended to represent a yellow stain, which has to be applied to the glass independently of the enamel shade; but it should be put on before the first burning. This may be effected by putting the silver on the back of the glass whilst the enamel is on the front.

When this has been completed, it will be found advisable probably to deepen some of the outlines, and to make the lines of the hair and drapery bolder, and better defined. This may be done with the oxide mixed with oil or turpentine. It must be remembered all through that the oxide is apt to come out a little less dark than it appears before it goes into the oven; but that, on the other hand, the shading on the flesh and other light portions is much more perceptible than on the darker and deeper colours, and therefore should be kept lighter.

SHIP-BUILDING.—V.

BY W. H. WHITE,
Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF WOOD SHIPS.

In accordance with the intention previously expressed, we will now begin our examination of the structural arrangements of ships at the framing, afterwards passing on to notice the skins and decks. In order to economise space, we shall deal briefly with the arrangements of keels, stems, stern-posts, and other pieces closely connected with the framing, while speaking of the latter.

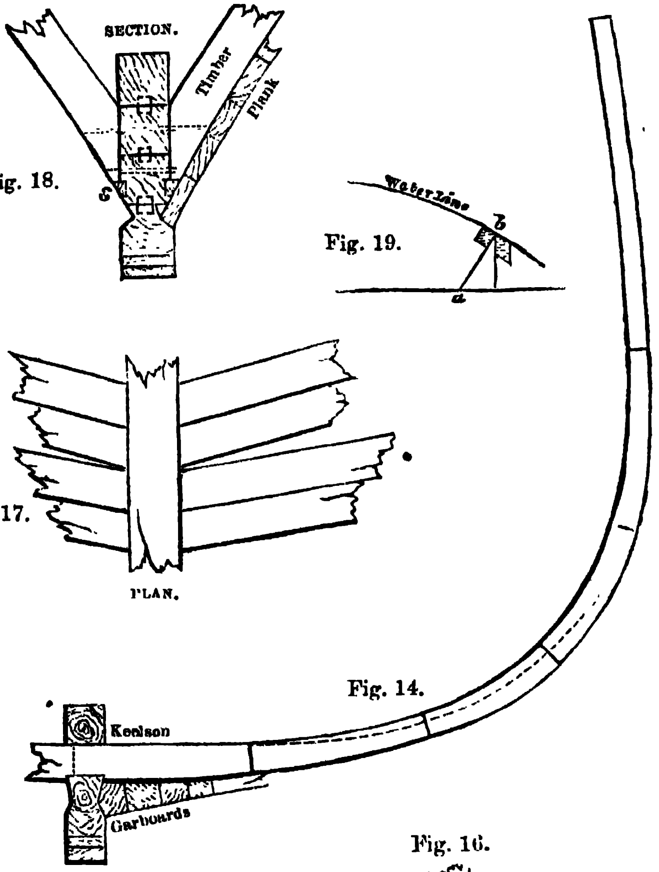


Fig. 18.

Fig. 19.

Fig. 17.

Fig. 14.

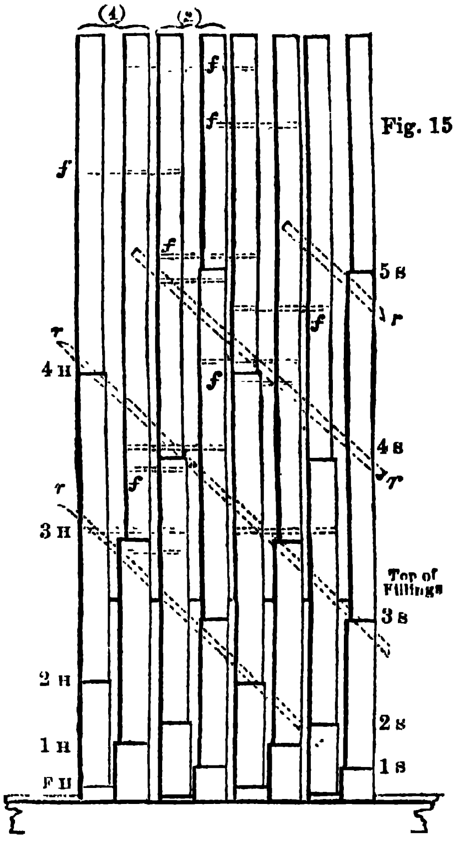


Fig. 15

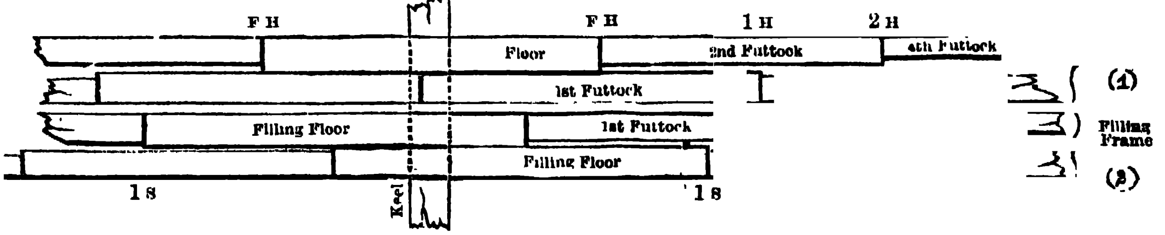


Fig. 16.

Wood ships have their frames arranged on different plans, but in all of these the great features are the same, and the differences existing are comparatively trifling. In all cases the curved frames are each made up of several solid timbers, joined to one another by one of the methods illustrated in Fig. 6, page 29; but different builders follow different plans in arranging the joints, as well as in securing them. Instead of attempting to follow out these plans in detail, we will select a good arrangement, and endeavour to show the principles upon which it is based, as well as to point out its distinctive features. Figs. 14, 15, 16 show such an arrangement in section, elevation, and plan, and we may add that it illustrates the system of framing usually followed in the Government service when wood ships were in vogue.

On reference to the plan (Fig. 16) it will be seen that the four timbers shown are bracketed in pairs, and named "frame" and "filling-frame." The distance from the centre lines of these two combinations is technically termed the "room and space," or "timber and space," and this distance would be fixed in the specification of the ship. The origin of the term is obvious, seeing that the timbers of the frame do not touch those of the filling-frame, a "space" or "opening" being left between them. Taking the frame first, it is seen to consist of a "floor," which crosses the keel, and has arms of equal length, ending on either side at the "floor-head" (marked F H in the figure). Upon the butt or end of the floor is fixed another timber, known as the "second futtock," and ending at the second head (marked 2 H); and upon this timber comes another, named the "fourth futtock," ending at the "fourth head" (marked 4 H); and so on. The corresponding arrangement in the elevation will be seen under the bracket marked (1).

The second set of timbers in the frame consists of "first futtocks" butted near the centre line of the keel, and extending out to the "first head" (marked 1 H); upon which come "third futtocks" ending at the "third head" (3 H); and so on. The sides of the adjacent floors and first futtocks are accurately fitted together, and these timbers are fastened to each other by dowels and bolts, so that the floor forms a strap to the butt of the first futtocks. The timbers above the floors and first futtocks are not, however, close-jointed in the case before us, and as they are of less "siding" (that is, smaller in the fore-and-aft direction) than the floors and first futtocks, "openings" are left, as shown in the plan and elevation. It will also be seen from the drawing that the butts of the two sets of timbers in a frame are made to "give shift" to each other; that is, the butts of one set are so placed as to be near the centres of the lengths of adjacent timbers in the other set: the advantage thus gained will be obvious.

Turning to the "filling frame," (2) quite another kind of combination presents itself. The butts of the timbers are here termed "sirmarks" instead of "heads," and are marked 1 s, 2 s, and so on. They are, it will be noticed, made to give shift not only to each other, but also to the butts of the frame-timbers. Beginning at the keel, we find a pair of "filling-floors" close-jointed to each other; these differ from the "floors" in having a long arm on one side, and a short arm on the other. Hence they are sometimes termed "long and short arm floors." The long arm of one filling floor is on the same side of the keel as the short arm of the other, and the two timbers are fastened to each other by coaks and bolts in the parts between the "floor sirmarks" (F S). The "futtocks," or lengths of timbers, are usually numbered on the principle shown on the plan shown in Fig. 16; the first futtock having its upper end at the second sirmark (2 s), the second futtock at the third sirmark (3 s), and so on. In this particular of nomenclature, however, no uniform rule is followed, and it is really a minor matter.

The elevation in Fig. 15 shows that on the line drawn through any particular head or sirmark there are always found *three* passing timbers between consecutive butts, and the arrangement described above of alternate frames and filling-frames is adopted in order to secure this result, and at the same time to assist the conversion of the timbers. Formerly in the Government service it was, and still in the merchant service it is, the practice to have frames only, no filling-frames being fitted, and as a consequence only *one* passing timber is found between consecutive butts on any "head-line." In some cases this disposition is carried out on the basis of the "floor and first futtock" combination, and in others on that of the "long and short arm floor" combination, with minor modifications that need not be described; but in all cases it is desirable when this plan is followed to have good lengths of timbers in the frames, in order to secure good shifts of butts in adjacent timbers.

In comparing an arrangement like that in Fig. 16 with one where no filling-frames are used, it is necessary to remember that the timbers of the frame are not easily procured, because of their size and curvature, and that no single set of timbers forming a continuous "bend" from keel to gunwale (like that shown in the section) has in itself the power to maintain its form. The first consideration is one connected with what ship-builders term the "conversion" of the material—in other words, its shaping from the rough log, and it is a most important one; and as the floors are the most difficult timbers to procure, it appears probable that from this point of view the arrangement of Fig. 16 is preferable, because it is easier to convert long and short arm floors than floors with arms of equal length. Besides this fact there is another which has to be borne in mind—viz., that the provision of *three* passing timbers between consecutive butts instead of *one* renders it possible either to reduce the lengths of the individual timbers while retaining the same amount of strength in the framing, or, keeping the same lengths of timbers, to add to the strength of the framing. In fact, an intermediate course may be followed if desired, and advantages gained both as respects ease and cheapness of conversion and strength. Greater freedom in making his arrangements of the futtocks is undoubtedly given to the builder by the more recent plan; and the fact that it has entirely supplanted the other in the Government service furnishes valuable support to its claims to superiority.

Considering the strength of a set of timbers, like those shown in the section in Fig. 14, to resist change of curvature—and excluding for the time all the aid given them by the skin and other parts of the finished structure—it is obviously but small; no matter whether the timbers have square butts with dowels (as shown by 1 in Fig. 6, page 29), or angle-chocks (as shown by 3 in that figure). The former plan, it should be stated, is now almost universally adopted in the wood ships of the Royal Navy, while the latter is often used in merchant ships. Scarfs, like 2 in Fig. 6, are only used in special cases: for example, where it is desired to give great strength against strains in the direction of the length of the timbers, such as occur in wake of the chain-plates to which the shrouds are secured. But while weak when taken alone, the "bends" of timbers, when well combined with those adjacent to them, can be made comparatively strong, and capable of maintaining their form. One of the means adopted for connecting the frames, and enabling them to give mutual aid, consists in the use of what are termed "frame-bolts," of which examples are shown by *f*, *f*, in the elevation in Fig. 15. These bolts are generally of square iron, and are driven fore and aft through two or more timbers, being placed so as to clear the skin-fastenings as much as possible. In the case illustrated, the heels of the timbers are secured to the timbers on each side of them, while the heads are secured to one of the adjacent timbers, usually to the other timber of the frame or filling-frame. Near the upper ends of the timbers the frame-bolts are longer, and form a tie to a greater number of timbers. In ordinary merchant ships it is customary only to make the frame-bolts pass through the two timbers of a frame, and not to make the connection extend to adjacent frames, except in special cases. The difference between the two plans of bolting is not of very great importance, but the advantage undoubtedly lies with the plan which ties most timbers together: this is termed "chain-bolting."

To develop the strength of the framing to the fullest possible extent, the timbers of the respective frames and filling-frames must, however, be directly connected to each other. The older plan, still followed by the French, is to fit the timbers of the respective frames with close joints, and to connect them strongly by means of dowels and bolts, just as the floors and first futtocks are usually secured. This plan, of course, renders the openings between the adjacent frames wider than they would be on the other system, but this is of little importance, whereas in point of strength the framing is much improved. Recently the practice has been revived in this country, and as a proof of its advantages it may be stated that frames so arranged can be lifted bodily into place instead of being built up timber by timber. Of course more work is entailed by the close-jointing, dowelling, and bolting, but all this work can be done with facility while the frame is lying on the ground, and the advantages gained probably counterbalance the additional work. The butts of each timber are then directly supported, or strapped by the timber fitted or "fayed" against it; and when hoisted into place the frames can, if desired, be quite as well chain-bolted to adjacent frames as they can be on the ordinary method.

Little need be said respecting the manner in which the frames are secured to the keel and keelson. It has already been stated that great care is taken to connect the several pieces forming the keel, and a sketch of the kind of scarf adopted has been given in Fig. 7, page 30 (scarf with tabling). From the sectional view in Fig. 14 it will be seen that the floors are "let down" a little over the keel; this being usually done by cutting away the keel for half the amount, and the floor for the other half. In the case of the filling-floors a similar plan is followed for at least one timber, but the whole amount by which the floors are "faced" or let down over the keel is usually cut out of the first futtocks. The latter are butted a little on one side of the middle line of the keel, and by this means room is obtained to place a dowel in the timber in order to secure it firmly to the keel. A dowel is also placed in the "seating" of one of each pair of floors, where it crosses the keel; and in the upper surface of the other filling-floor a dowel is fitted to connect it with the keelson, a similar connection being made between each floor and the keelson. Bolts are also driven through the keelson, floors, or filling-floors, and keel to strengthen the connection.

Keel, framing, and keelson are thus firmly combined. The keel projecting from the bottom enables the vessel to find a continuous support when building, or when docked, and aids slightly in checking her rolling or drifting to leeward when afloat. The false keel, fitted in two pieces, is only lightly secured to the keel proper, so that it may be easily detached without injury to the ship if she strikes the ground. Structurally considered, the keel forms a longitudinal piece of the framing, and in this respect it is aided by the keelson, which also is of service in receiving the heels of the pillars supporting the deck-beams.

The thick planks, marked "garboards" in the sectional view in Fig. 14, deserve separate mention here, although they are not always, or often, fitted in merchant ships. One advantage of fitting them will be obvious at a glance—viz., that the floors required are of less depth near the keel, and are less faced down upon the keel than they would be if the same outside form were retained, and the bottom planking made uniformly thick down to the keel. In addition to this the garboard strakes are valuable as strengthenings to the lower part of the ship, being efficiently fastened to each other as well as to the frames and the keel.

Throughout the greater portion of the length of a wood ship, the system of framing would be identical with that described, the only changes being those due to alterations in the forms of the transverse sections. Near the bow and stern, however, where the ship becomes rapidly narrower, and the water-lines are (as shown by the half-breadth plan in Fig. 12, page 61) far from being parallel to the middle line of the ship, it becomes necessary to make considerable changes. Instead of retaining the transverse position which all the amidship framing has, the frames are "canted," so that they may stand nearly square to the water-lines, and not require much "bevelling." This will be seen at once on referring to the sketch in Fig. 19, the drawn lines in which show the section of the canted timber (of which the line *a b* is the "stand"), and the dotted lines the form of section that would be required if the frame stood transversely. Although canted in the transverse sense, the frames remain vertical; in fact, the change of position will be clearly understood when we say that it is exactly that which would take place if the transverse frame shown in the sectional view in Fig. 14 were made to swing round a little about the middle line. The amount by which the timbers are canted, of course, increases as they approach nearer to the extremities; at first the departure from the transverse direction would be scarcely appreciable, but at the extremities it would be very considerable.

With cant-timbers it would obviously be difficult to continue the system of floors and filling-floors; and it would be practically impossible to do so when they are much canted. For example, the plan in Fig. 17 shows that the corresponding cant-timbers on opposite sides of the keel, being equally inclined to the keel, could only be formed out of a very large piece of timber, and that it would be folly to make the attempt. Besides this, there is the fact that near the extremities the vertical sections of a ship become more or less V-shaped, as shown by the section in Fig. 18, so that, irrespective of the canting of the frames, it would be most undesirable to endeavour to make them cross the keel. The ship-builder makes no such attempt, but by a very simple arrangement provides sufficient strength, as well as comparatively easy forms for the conversion of his material. In some cases, one or more "cant-floors," as they are termed, are fitted, but their use is not common.

Where the transverse frames end, or in technical language where the "square body" terminates, the space between the keel and keelson is filled by a longitudinal timber, strongly fastened by dowels and bolts to both, and forming the commencement of the "deadwood." This deadwood increases in depth as the extremities are approached, and has to be made up of two or more pieces in depth; consequently care has to be taken, not only in disposing its scarfs (which are plane) in relation to the scarfs of the keel and keelson, but also in bolting and dowelling the various parts in order to form a compact mass. The cant timbers heel against the sides of the deadwood (as shown in Fig. 18), and are dowelled and through-bolted to it. As the sections become more and more V-shaped, the heeling of the cants becomes deeper, but in no case should a sharp lower edge be left to the heel, and it is usual either to fit a "stepping piece" (marked *s* in Fig. 18), or to let the heels slightly into the deadwood in order to prevent this. When the plank is brought on outside all, additional fastenings are driven in the heels of the cants.

The disposition of the various heads and sirmarks in the square frame is carried out also in the cant bodies, where the timbers are arranged in pairs constituting frames and filling frames, with a common centre line or "moulding edge" to each pair. Near the extremities, where the ship's form is fine, and the girths of the frames are very much less than they are nearer amidships, it is customary to omit some of the butts, and to have what are termed "double-futtocks," that is, single timbers running between heads or sirmarks, which would be so far distant at the midship section as to require two timbers or futtocks between them. The lower water-lines are also much finer than the upper ones, and consequently the space to be filled by the lower cant-timbers is much less than that spread over by the upper timbers of the same number of frames. Hence it is necessary to have the lower timbers close-jointed, and to reduce their siding considerably.

The cant-frames of the fore body extend right forward; between the foremost cant and the stem, it is usual to fit a single timber, called the "knight-head," another termed the "stem-piece" being occasionally fitted in large ships. The foremost boundary of the structure is the stem itself, which in most cases has considerable curvature, and consequently has to be formed out of several pieces of timber joined by scarfs; the lower piece being scarfed to the foremost end of the keel, by what is termed a "boxen scarf." Within the stem, and closely fitting against it, lies the "apron"—a sort of inner stem of which the scarfs are carefully shifted with respect to those of the stem, in order that the two pieces may mutually support each other. The lower end of the apron is generally scarfed to the deadwood, of which it thus forms a continuation similar to that of the keel by the stem. In large ships further strength is given to the bow by means of the "stemson" fitted inside the apron, and connected with the foremost end of the keelson. The mass of timbering thus formed is fastened together by numerous dowels and through-bolts; and it is further secured to the framing on either side of the bow by means of strong breast-hooks, crutches, etc., stretching from side to side, and bolted to the timbers. The deck framing also forms a strong connection between the two sides, and altogether the arrangements made are, in well-built ships, as satisfactory as they can be with wood as the material used. It will be seen, however, that in iron ships no such elaborate combinations are required as the deadwood, apron, stemson, etc., of a wood ship.

Respecting the after-body, little need be said. The cant-frames usually end at or near the stern-post, although in some cases they extend around the stern also. The stern-post of a wood ship usually consists of several timbers strongly fastened together by tabling and through-bolts. The lower part, or heel, of the post is generally connected with the keel by means of mortises and tenons, and by diagonal bolts driven through the deadwood, post, and keel. The upper part of the post is secured to the counter-timbers, and in some cases to the deck-beams also. All these connections are, however, matters of detail, and they depend largely upon the character of the vessel, whether she is a sailing ship, a paddle-wheel vessel, or a screw steamship. If a screw steamship, she would probably have two stern-posts, with the propeller placed between them, and the rudder hung to the after post; in either of the other cases there would only be one post, to which the rudder would be hung. The after-ends of the timbers forming the deadwood are tenoned into the post, and a similar plan is followed with the keelson. Sometimes the latter connection is strengthened by a stemson, corresponding to the stemson at the bow. Iron hooks and straps are used here also to assist in uniting the two sides.

The outlying part of the stern abaft the post varies considerably in form, and also in the character of its framing. Much has been said and written respecting the stern framing of wood ships, and it is a matter requiring care on the part of the ship-builder; but it has little to do with the strength of the ship as a whole, and therefore only a few words can be said respecting it here. In square-sterned ships, "transoms" (or timbers lying almost horizontally) are commonly used, in combination with other vertical or oblique timbers of which the sides stand fore and aft. In ships with elliptical sterns, the stern-timbers are really "double cants," their sides lying in planes inclined both to the vertical and the horizontal. In other cases, as was said above, the whole stern is framed with ordinary cants. Whatever plan of framing is adopted, means have to be provided for strongly tying the overhanging stern to the main framing. A favourite means of doing so is by using iron riders, or tie-plates, which reach round the stern-frames on the outside, and stretch forward over the cant-frames, being bolted to all the timbers they cross. On the decks also iron tie-plates are sometimes fitted, and inside the frames crutches and hooks of various kinds are placed to strengthen the connection. In screw steamers especially is it necessary to strengthen the stern to resist the strains caused by the propelling apparatus; and this object is best accomplished by means of iron strengthenings, examples of which may be given hereafter if space permits.

FARMING AND FARMING ECONOMY.—VIII.

By Professor Wrightson, Royal Agricultural College, Cirencester.

THE CEREALS: WHEAT.

Botanists are not agreed as to the original parent form of any one of our cereals. Mr. Darwin, after boldly facing this difficult question through several pages of his "Animals and Plants under Domestication," writes: "Finally, every one must judge for himself whether it is more probable that the several forms of wheat, barley, rye, and oats are descended from between ten and fifteen species, most of which are now unknown or extinct, or whether they are descended from between four and eight species, which may have either closely resembled our present forms, or have been so widely different as to escape identification." Could any summing-up be less satisfactory? That wheat has been cultivated from the most ancient times, may be proved from many passages in the Bible, and by evidence gathered from the lake habitations of Switzerland, where wheat was well known when men employed only flint tools.

According to Vilmorin, the cultivated wheats may be classified under seven species:—

Triticum sativum, both bearded and beardless, with many red, white, and yellow sub-varieties.

Triticum turgidum, with simple and with compound ears, and red, white, or intermediate sub-varieties.

T. durum, with three varieties.

T. polonicum, consisting of one type only.

T. amyleum, consisting of one type only.

T. monococeum, consisting of one type only.

T. spelta, with a bearded and a beardless variety.

T. sativum embraces all the varieties cultivated in this country, with the exception of some coarse large-yielding sorts known as cone-wheats and Egyptian wheat. The number of kinds of wheat is very great. Dalbret cultivated during thirty years from 150 to 160 varieties, Colonel Le Couteur possessed upwards of 150, and Phillipar 322. The number of sub-varieties appears capable of unlimited extension, since not only each ear, but each grain of special character is, according to Colonel Le Couteur, able to transmit its peculiarities, and originate a sub-variety with more or less fixed character. These varieties differ from each other in the colour, form, weight, or quality of the grain; the shape of the ear, some being square, while others are cylindrical, compressed (flattened), or tapering; in a closer or wider arrangement of the florets; in being bearded or beardless; in the roughness or smoothness of the chaff scales; in the length, strength, and hollowness of the straw; in the breadth of the foliage; in habit of growth, some being upright while others are more recumbent, and in their hardihood and adaptation to peculiar conditions of soil and climate. The following tables of the principal varieties, with their leading characteristics, contain some of the principal wheats cultivated in this country.

I.—WHITE BEARDLESS VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
A 1.		Rough.	Short.	Fine and plump.	
Brodie's.			Medium.	Fine, plump.	
Chiddam.	Square.		Long, stiff.	Short, compact, fine, plump.	Adapted for soft, good soil.
Corners.	Square.	Rough.		Fine, plump.	
Cluster, dwarf.	Compact, thick.		Short, stiff.		For rich soils.
Dantzic white.	Moderately compact.	Thin, smooth, white.	Tall, slender.	Oblong, translucent.	Obtained by Col. Le Couteur.
Earl Ducie's.	Square.	Smooth.	Medium.	Good quality.	
Essex.	*See* Chiddam.				
Fenton.	Square, upper florets slightly awned.	Smooth.	Short, stiff, unequal in length.	Pale, white, round, plump.	For rich soils.
Hallett's.	Square heads.	Rough.	Medium.	Fine, plump.	Improved by selection.
Hopetown.	Long, slightly tapering.	Smooth.	Long, stiff, white.	Bright, plump, transparent.	
Hunter's.	Tapering to neck and point.	Smooth.	Medium.	Brownish, large, elongated, heavy.	For medium and inferior soils.
Morton's red strawed white.	Square, long, close.	Red.	Streng, reedy, red.	White, round, plump.	
Mongoswells.	*See* Hunter's.				
Malaga.	Compressed, tapering, florets wide apart.		Long.		
Oxford prize.	*See* Chiddam, which it closely [resembles.				
Pearl.	Very square.		Long, stout, white.	Heavy, firm, plump.	For rich soils.
Red chaff white.	Square.	Reddish, smooth.	Short.	Fine.	For rich soils.
Salmon coloured.	Tapering, compressed.	Smooth.	Long.		
Suffolk white.		Smooth.	Long.		
Talavera.	Long, florets far apart.	Smooth.	Long.	Long, coarse, translucent.	For good land.
Trump.	Square, compact.		Short.	Fine.	
Velvet, or Woolly-eared.	Small, close, compact.	Rough.	Short.	Translucent, whitish or brownish.	For rich loams.

II.—WHITE BEARDED VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
Californian white.	Close, compact.		Short.	Fine.	
Sherriff's.	Square.	Smooth.	Medium.	Red.	

III.—RED BEARDLESS VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
Australian.	Cylindrical, tapering.	Smooth, yellow.	Fine.	Red.	
Browick.	Square, bold.	Smooth.	Strong, medium.	Strong, good.	For medium and poor soils.
Burwell.	Compressed, tapering.	Smooth.	Longer.	Red.	For medium soils.
Creeping red.	Tapering, narrow, cylindrical.	Smooth.	Long.	Small, fine.	For poor soils.
Golden drop.		Red, smooth.		High in the back.	
Lammas.	Cylindrical, tapering.	Smooth.	Medium.	Long, fine.	For good land.
Monmouth.	Square, bold, slightly tapering.	Smooth.	Medium.		
Piper's thick set.	Very compact.	Smooth.	Short, stiff.	Tapering.	For good land.
Dark yellow.	Narrow, tapering, cylindrical.	Smooth.		Long, narrow.	
Spalding.	Square, flattened, slightly tapering.	Smooth.	Strong.	Yellow, large, coarse.	Clays, and soft peat soils.
Tibbalds.	Square, tapering.	Smooth, dark red.			
Kessingland.	Cylindrical, tapering.	Smooth.	Medium.	Coarse, red.	
Nursery.	Cylindrical tapering.	Smooth, whitish.	Medium, fine.	Small, fine.	Good spring wheat.

RED BEARDED VARIETIES.

Name.	*Ears, or Heads.*	*Chaff.*	*Straw.*	*Grain.*	*Remarks.*
Californian yellow.	Long, narrow, tapering.	Whitish, smooth.	Fine, short.	Red.	
Cape bearded.	Narrow, cylindrical, tapering.		Long, fine.	Translucent brown.	
Sherriff's.	Compact, square.	Red, smooth.	Medium.	Red.	
April.	Pointed, spreading.		Tall rye-like straw.	Longish.	For late sowing.
Mummy.	Branched.			Coarse.	
Rivett's cone.	Short, compact.	Rough, red.	Solid.	Coarse.	For poor clay, yields largely.

In treating of wheat cultivation we shall consider—(1) the place which the plant occupies in rotations; (2) the soils most suitable for its development; (3) the preparation of the ground; (4) the season of sowing; (5) the quantity of seed used per acre; (6) the methods of sowing; (7) the after cultivation; (8) the harvest; and (9) the cost and return.

PLACE IN ROTATION.

This is usually fixed for tenants by definite clauses, stipulating that no two white crops shall occupy the same ground consecutively; or, still more minutely, the exact position of the various crops towards each other in prescribed rotation. Such restrictions and prescriptions have a certain value on ill-farmed estates, where bad land and poor, uneducated tenants are united under a needy landlord; but they will disappear precisely as good farming extends, and intelligent, well-to-do-tenants increase in number. In ordinary good farming, wheat will follow a bare fallow on stiff soils, or a portion of the root and green fallow. Thus vetches may be consumed on the land as a preparation for wheat, and mangel-wurzel, potatoes, and turnips, consumed early in the season, will leave the land at liberty for winter or spring sowing. Land which has borne a root-crop will, as a rule, be planted with corn of some kind, and the amount set aside for wheat will vary with the season and the natural quality of the soil. Thus clay soil cleared of its root-crop will be suitable for wheat, while light soils, especially when the root-crop is uneaten until late in the season, will be best sown with barley. Over the greater part of the south, west, and east of England, wheat follows one or two years' grass; while in the north, and in Scotland, oats are often taken at this period of the course, while a large breadth of wheat is planted after roots and fallow. Beans also form an excellent preparation for wheat, and cases are not wanting in which strong soils have been cropped for many years alternately with wheat and beans. Wheat has also been grown many years in succession upon the same land, and there is reason for believing that upon some clay soils such a system, aided by steam cultivation and liberal manuring, might be pursued with success.

WHEAT SOILS.

Reference to the above list of varieties will show that there are wheats adapted to almost every kind of land, from peaty, black, soft soils, to hard, poor clays. The stiffer classes of soils have received the general appellation of "wheat lands," because they grow this crop with marked success, and also because they are not adapted for barley and turnip cultivation. Folding sheep upon turnips will give a consistency to even the lightest soils, enabling them to grow wheat and other corn crops successfully.

PREPARATION OF THE GROUND.

Wheat after bare fallow should be sown early in September. This order of cropping presupposes stiff clay soil, and on such soils the earlier the seed is planted the better.

Wheat after roots receives the benefit of all the cultivation bestowed upon the roots. When these are carted off, or fed on the land, plough three to four inches deep, harrow, and drill. A fresh furrow is preferred.

Wheat after Clover.—Eat the pastures bare by means of ewes or other store stock, and plough early, so as to ensure a stale or old furrow. In some cases ploughing is done at the beginning of August, or even earlier; and as a general rule, you can hardly begin too soon. Crosskill or Cambridge roll immediately, to kill the grass and render the ground firm. Harrow repeatedly before and after the drill.

Wheat after Beans.—Cart twelve to fifteen loads of dung on to the bean stubble, plough, and harrow, previous to sowing.

Wheat after Potatoes.—Plough or lightly cultivated, harrow and sow. Land is often too light or hollow after potatoes for wheat; hence deep ploughing is to be avoided.

We cannot recommend indiscriminate deep tillage for wheat. However advisable such a method of cultivation is for stiff soils, over large tracts of light and medium soils it is best to stir the ground deeply for root-crops and plough lightly for cereals.

THE SEASON OF SOWING.

In fallow land, wheat should be sown before the end of September. Root land may be prepared for winter, and spring wheat from October to March, and even up to April. Lea or clover land is best planted with wheat in October and November. Bean land should be sown with winter wheat as early as convenient in the autumn.

THE QUANTITY OF SEED.

Probably no point of farming practice has been more keenly discussed than this. Some of our teachers insist on two pecks per acre of seed as the proper quantity, while others recommend eight pecks. The "thin sowers" have certainly succeeded in reducing the amount of seed used in ordinary practice, just as enthusiastic teetotalers have had their effect on public opinion in the matter of alcoholic drinks, but it is scarcely likely that the amount of seed will be further materially reduced. When we have good land, seeded early in the autumn, the minimum quantity of seed may be used. Experiments have frequently yielded results opposed to thin seeding. Mr. P. Sherriff, who is one of our best authorities on wheat, says: "Respecting the quantity of seed, I can testify from experience and observation . . . that a 'thin plant' . . generally enlarges the ears and corns, retards ripening, and aggravates the effects of red gum and mildew, while the straw is shortened both by a very 'thick' and a very 'thin' plant."* Mr. Blyth, of Sussex Farm, Burnham, Norfolk, during 1839, 1842, 1843, obtained uniformly better results with seven-inch drills and ten and a half pecks per acre, than with nine-inch drills and eight pecks per acre.† T. W. Brampston, Esq., M.P., in 1838 found narrower drilling and a larger amount of seed better than wide drilling and less seed.‡ Mr. W. Loft found eight pecks per acre gave a better crop than five pecks per acre.§ Mr. R. Birch Wolfe, after trying both systems, says the balance is in "favour of narrow drills, seven inches, and the larger amount of seed by seven bushels and seven quarts per acre." ‖ Also Mr. J. F. Burke writes: "I have tried many experiments on sowing wheat on a large farm in the north of Germany, and always found thick sowing was best on the light porous soils, but on clays thin sowing was better."¶

The Cirencester Chamber of Agriculture came to a similar conclusion after a series of experiments carried out by its members in 1869, and we may consider that any attempt to introduce a general system of thin sowing—*i.e.*, less than six to eight pecks per acre—will be attended with loss. Nevertheless, the results obtained by Mr. Mechi, Mr. Wilkins, and the late Mr. Hewit Davis are remarkable, and show the necessity of each farmer testing the requirements of his own land as to quantity of seed.

METHODS OF SOWING.

Drilling, by means of the Suffolk or other corn drills, is the most usual method of planting wheat. It has so completely superseded broadcast sowing in most districts that it is frequently difficult to find a man who thoroughly understands the use of the "seed-lip."

Broadcasting has many points to recommend it. It is a rapid and cheap method of sowing: the treading of horses may be thus avoided, although on much of our lighter soils this is a questionable advantage: the seed is more uniformly distributed than in drilling in rows; the crop is equally successful. When combined with "ribbing," or the formation of small ridgelets, hoeing between the rows may be resorted to. On the other hand, the *drill* has superseded the older system on account of its precision in width, depth, and quantity of seed sown, and the facilities it offers for hoeing.

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* Vol. II., *Royal Agricultural Society's Journal*, page 344.
† Vol. V. *ibid.*, p. 352. ‡ Vol. I. *ibid.*, p. 294. § Vol. IX. *ibid.*, p. 281.
‖ Vol. IX. *ibid.*, p. 453. ¶ Vol. IX. *ibid.*, p. 454.

Dibbling, or depositing one or more grains in holes at a fixed distance apart, is recommended by the advocates of thin sowing as economical of seed. For early autumn sowing on good land it may answer, but it is a risky method of sowing.

Ploughing in is sometimes adopted with good effect. The wheat is sowed broadcast on the surface, and covered with a light furrow. This secures a firm bed for the wheat, a condition generally favourable to the development of the crop.

PREPARATION OF THE SEED.

Wheat is "pickled" or "steeped" before sowing. This is best done with sulphate of copper or blue vitriol, 1 lb. of which is dissolved in 2 gallons of water for every quarter of wheat. A sufficient quantity of the solution having been made, the seed is lowered into it in a basket for a few seconds. The light grains which rise to the top are skimmed off, and the basket is withdrawn and allowed to drain. The wheat is then thrown on to a floor, and turned over with a shovel until it is dry. This process is used in order to destroy the germs of fungi in contact with the seed, which if unchecked would subsequently develop into "bunt" or "smut."

THE AFTER CULTIVATION.

consists in spring rolling, and, when the land is foul, in horse and hand hoeing. On stiff soils wheat is often benefited in the spring by harrowing, especially if, owing to rapid alternation from wet to dry weather, the soil has become set into a crust or scrap on the surface around the young plants. These tillage operations should only be attempted when the ground is dry. If the plant is thin and weak, 1½ cwt. of nitrate of soda or sulphate of ammonia may be applied with good effect in showery weather in April. Should the plant be too luxuriant, it may be checked by eating it down bare with sheep. This should not be attempted after mid-April. Flagging consists in removing the heavy foliage by means of hooks or scythes when it is seen to be likely to cause the crop to "lodge" or fall. This is done in May, and is so conducted as not to injure the young ear, whose position in the straw should be ascertained in order to guide the operator. Common salt is sometimes used as a top-dressing for checking the over-luxuriance of straw, and may be applied in April or May at the rate of 2 to 3 cwt. per acre.

HARVESTING.

The bloom or flower appears upon the young ear six weeks before harvest. This flowering period is considered critical, and requires quiet, genial weather. Sudden changes of temperature or high winds do incalculable injury. The proper period for cutting is indicated by the characteristic colour of the straw and the condition of the grain.

The old-fashioned practice was not to cut until the corn was dead ripe—"goose-necked," as it was called, on account of the bent appearance of the head and upper portion of the straw. It has, however, been demonstrated that there are serious disadvantages in thus delaying harvest operations. Not only is an important work postponed to a season when the weather is less certain, but we run the risk of loss from winds blowing out the grain.* The straw also becomes harder and less useful as fodder for stock, while the skin of the grain thickens so that less flour and more bran is yielded. The best period for cutting is when the grain, although soft enough to yield to the pressure of the thumb and finger, does not when squeezed exude a milky juice, but a pasty, semi-solid mass.

Machines are now in general use for cutting corn of all kinds. We cannot pause to inquire into the history of the reaping-machine, or even to compare the relative merits of the many forms before the public. The advantages of this mode of cutting are, however, sufficiently evident, and may be summed up as follows:—A cheaper and quicker method than either sickle or scythe; the employment of horses at a time when they were formerly idle; diminished risks, especially from wind. Side delivery machines, which leave the corn in bundles ready for tying up, such as are sent out by Hornsby of Grantham, or Samuelson of Banbury, are the best for wheat; while a machine like Burgess and Key's, which leaves a continuous swathe, is most suitable for barley.

If the weather is unsettled, the wheat should be at once tied up and stacked; but in fine weather it will be all the better for lying a few hours in "broad-band." Sheaves should be of good form, with all the heads at one end, square at the butt, and tied tightly, rather nearer the butts than the heads. Stooks should be composed of six pairs of sheaves each, firmly set down, pointing south-west and north-east, and the stook rows should be straight. The time required for drying the corn is variable. Sometimes it may be cut and carted at once, while at other times a fortnight will elapse before it is "fit." Wheat is fit to cart when the straw is dry at the nodes or knots, and when the grain is hard. If it is required for marketing at once, it must be dry enough for grinding; but if it is intended to stand in the stack-yard over winter, it need not be in such good "condition." In carting we may either stack in the field or carry to the rick-yard. In either case we shall require one man pitching in the field, one man pitching at the stack, one boy loading carts in the field, one man making the rick, one woman raking in the field, one to three people assisting on the stack, and carts according to distance. The cost of harvesting may be thus estimated:—

	s.	d.
Cutting by machinery	1	6
Taking up, tying, and stooking	4	6
Pitching and loading	1	0
Rick-building	0	8
Carrying	0	8
Thatching	1	4
Total per acre	9	8

Harvesting requires close attention from the master, who will find his judgment continually exercised in watching the weather, determining when to cut or cart, and superintending the work-people. We conclude this brief account of wheat cultivation with an estimate of the cost of growing a crop of wheat after lea, and of the probable return:—

		s.	d.
Ploughing		8	0
Crosskill rolling		1	3
Harrowing before and after drill		2	0
Drilling		1	10
Seed, 2 bushels per acre, at 6s.		12	0
Rolling in the spring		0	9
Hoeing		3	6
Harvesting		9	8
Threshing		6	0
Marketing		5	0
	£2	10	0
Rent, taxes, etc.	1	15	0
	£4	5	0

The probable yield may be taken at 30 bushels, and the price at 6s. per bushel. This will give a return of £9 per acre, and apparently a handsome profit. In order to arrive at a true idea of profit, it will be necessary to take the whole rotation into account, as some crops, such as the one under consideration, although profitable, are preceded and followed by unremunerative or possibly losing crops.

NOTABLE INVENTORS AND INVENTIONS.

XXIV.—THE MARQUIS OF WORCESTER AND HIS "CENTURY OF INVENTIONS" (*concluded*).

BY JOHN TIMBS.

52. *A mystical jingling of church bells*, by which, varying the order of arrangement, the whole alphabet may be rung on three bells; and these, being formed into sentences by short pauses between each word, will fully serve for distant conversation. For musical instruments, it is merely changing keys for bells.

53. *A hollowing of a water-screw;* a leathern water-pipe, nailed in a spiral form round a long circular pole, the most simple method of making the Archimedean screw.

54. *How to make a water-tight screw;* by making a coarse screw and covering it with horn, or fitting a spiral tube of glass on a wooden cylinder, and filling up the interstices with wax or any hard cement, so as to project beyond the glass tube.

55. *A double water-screw*, the innermost to mount the water, and the outermost for it to descend more in number of threads, and consequently in number of waters, though much shorter

than the innermost screw, by which the water ascendeth, a most extraordinary help for the turning of the screw to make the water rise. How a larger quantity of water can descend than has previously risen it is hard to say.

56. *An advantageous change of centres;* all the weights of the descending side of a wheel being perpetually further from the centre than those of the mounting side, and yet equal in number and heft of the one side as the other: tried before the King and court by the Marquis's directions, in the Tower. The experiment was made more than fifty years prior to that of Orffyreus, a German mechanic, whence he is presumed to have derived the idea from the Marquis's work.

57. *A constant water flowing and ebbing motion,* upon the principle of an ebbing and flowing spring. The throwing in of a ball, by causing a commensurate rise of the water, fills a syphon, and sets the water-work in motion; but as the effect of this would soon cease after the two vessels attained an equilibrium, the machine must be assisted by a moving power attached to one or both of the vessels, as the Marquis merely says that it may be performed "without the help of any man *within sight or hearing.*"

58 to 67. *Improvements of considerable importance in the principle of modern fire-arms.* One invention, the effect of electricity applied to gun batteries.

68. A fire water-work, already described.

69. A triangle key.

70. A rose key.

71. A square key, with a turning screw.

72. An escutcheon for all locks.

73. *A transmittible gallery* over any ditch or breach in a town wall, with a blind and parapet, cannon-proof.

74. *A conceited door,* whereof the turning of a key, with the help and motion of the handle, makes the hinges to be of either side, and to open either inward or outward, to enter or to go out, or to open in half. By making the handle act on a lever communicating with the hinges, they may be raised from their sockets on the required side, and to open in half they are jointed in the centre.

75. How a tape or ribbon weaver may set down a whole discourse without knowing a letter. (See 33, 34, and 35.) It may be performed either by making the stitches of a given length, varying the distance; or by any shape agreed upon by the parties, when the silk weaver will have only to set his loom to the required pattern.

76. *How to write in the dark,* as straight as by day or candle light. "Two planes of ebony of equal length and breadth, similar to the parallel ruler, joined at each end by racks, the side of which being graduated to the width of the line intended, will serve as a certain guide; and by the use of this instrument a blind person may write with the greatest accuracy. If ivory tablets or a slate is used, a fine wire drawn with a steel point may be readily felt by the point of the pencil."—*Partington,* note.

77. *How to make a man to fly;* which the Marquis tried with a little boy of ten years old, in a barn, from one end to the other, on a hay-mow. Upon this Mr. Partington has a note of six closely-printed pages, from which we can only quote that the whole problem of aërial navigation is confined within these limits, viz.: "To make a surface support a given weight by the application of power to the resistance of the surrounding atmosphere." The subject is, however, far beyond our limit.

78. *A watch to go constantly,* yet needing no other winding from the first setting. It will be necessary to employ a small balance, with a nut attached to its axis, and communicating with the fusee, the continued vibration of which will, by winding the watch, give it nearly all the advantages of a perpetual prime mover.

79. *A way to lock all the boxes of a cabinet at one time;* to be performed either by cranks and wires, or by sliding bolts and levers communicating with each lock. A more simple mode is the use of a series of spring locks, which may be closed by the pressure of the lid, unconnected with any other mechanism.

80. *How to make a pistol-barrel no thicker than a shilling,* yet able to endure a musket-proof of powder and bullet.

81. *A comb conveyance* for carrying letters without suspicion, the head being opened with a needle screw drawing a spring towards one.

82. *A knife, spoon, or fork,* in a portable case, may have the like conveyances in their handles.

83. *A rasping mill for hartshorn,* for which a variety of engines have been invented.

84. *An arithmetical instrument,* whereby persons ignorant of arithmetic may perfectly observe numeration and subtraction of all sums and fractions. The unfinished calculating instrument of the late Charles Babbage is, however, much superior to any other contrivance yet suggested, unless it be Scheutz's difference engine.

85. *An untoothsome pear,* which being dexterously conveyed or forced into a body's mouth, shall shoot forth so many steel bolts at each side, and at both ends; can neither be opened nor filed off. This discovery may be set down as useless.

86. *An imprisoning chair,* in which a stranger seating himself, has immediately his arms and thighs locked up, beyond his own power to loosen them. "Chairs of this description," says Partington, "were employed by the monks in the darker ages of Christianity, to entrap curious persons; they were provided with two levers at the extremity of the arms, and the same number were fixed immediately below the seat. These, on pressing the cushion, were discharged like a man-trap, by four powerful springs acting on the lever, so that it would take the united force of four or five persons to free the prisoner."

87. *A brass mould to cast candles,* in which a man may make 500 dozen in a day.

88. An engine, without the least noise, knock, or use of fire, to coin and stamp 100 lbs. in an hour by one man. The Marquis was ignorant of Boucher's fly-press for multiplying metallic impressions from an engraved surface.

88*. *A brazen head* that answereth a whisper into his ear, in French, Latin, Welsh, Irish, or English, uttering it out of his mouth, and then shut it. But this invention has been transcended by the Invisible Girl of our day. Partington's descriptive note is very interesting. but too long for quotation.

89. *White silk gloves,* knotted in the fingers, with which a card-player may, by the knots or rings, keep reckoning of all sixes, sevens, and aces, which he hath discarded, and without false play.

90. *A dicing box,* with holes transparent, and by a knock of it against the table the four good dice are flattened, and it looseneth false dice made fit for this purpose.

91. *An artificial horse,* on which a man being mounted, he can make him start, and run at the ring—an automaton figure.

92. *A gravel engine,* made like a water-screw.

93. *The water canal.* An engine whereby one man may take out of the water a ship of 500 tons, so that it may be caulked, trimmed, and repaired, without need of the stocks, and as easily let down again.

94. *A little portable engine,* called a jack, for opening a door or gate; its even, uniform motion is clearly described by the Marquis of Worcester.

95. *A double cross-bow,* to shoot two arrows in immediate succession.

96. *A way to make a sea-bank,* described precisely by the noble inventor, in its results, like the Breakwater at Plymouth.

97. *A perspective instrument,* answering the description of the camera obscura and camera lucida.

98. *The semi-omnipotent engine,* so contrived, that working the *primum mobile* forward or backward, upward or downward, circularly or cornerwise, to and fro, straight, upright or downright, yet the pretended operation continueth and advanceth, none of the motions above mentioned hindering, much less stopping, the other, etc. etc. (See page 43.)

99. *A most admirable way to raise weight.* How to make one pound weight to raise one hundred as high as one pound falleth, and yet the hundred pounds descending doth what nothing less than one hundred pounds could effect.

100. This, "the most stupendous work" of the whole "Century," has already been noticed (page 43). Whatever may be the worth of the majority of the "Century of Inventions,"[*] it is now a generally accepted fact that the Marquis had worked out in his mind a clear conception of a steam-engine, as we should now call it; and he is believed, shortly before his death, to have set at work a model of a steam-engine, from which, it is believed, Savery took his hints of the engine, which, since Watt's improvements, has remained "the only tame giant that is usefully subject to the will of man."—*Hawkshaw.*

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[*] Since the publication of Partington's edition has appeared the exhaustive "Biography of the Marquis of Worcester," by Mr. Dircks, C.E.

TECHNICAL DRAWING.—LIV.

GOTHIC STONEWORK.

EARLY ENGLISH WINDOWS (*continued*).

THE separate lights of these windows are generally placed at some distance apart on the exterior, so as scarcely to appear as if belonging to the same window; but in the interior, owing to the great splay given to each light, the distance between them appears inconsiderable, giving them the appearance of a single compound window.

In windows of three lights, such as that from Stanton Harcourt, Oxfordshire, shown in Fig. 476, the centre one is almost always the highest, its head rising considerably above the others, so as to preserve the arched appearance of the whole. Windows of four lights, with centre pair rising above the outer ones, are occasionally met with, but the most general by far are those of three, five, or seven lights, rising in height to the centre one. These lights were sometimes gathered under a single arched dripstone, as in the west window of the south aisle of Oundle Church, Northamptonshire, and covered by a dripstone, which, like the string-course already alluded to, covers first one light, is carried on horizontally, rises to the level of the springing of the next, follows the arch, descends to the level of the next springing, and so on, producing a very graceful effect. The window shown in this illustration is an excellent example of this kind of dripstone.

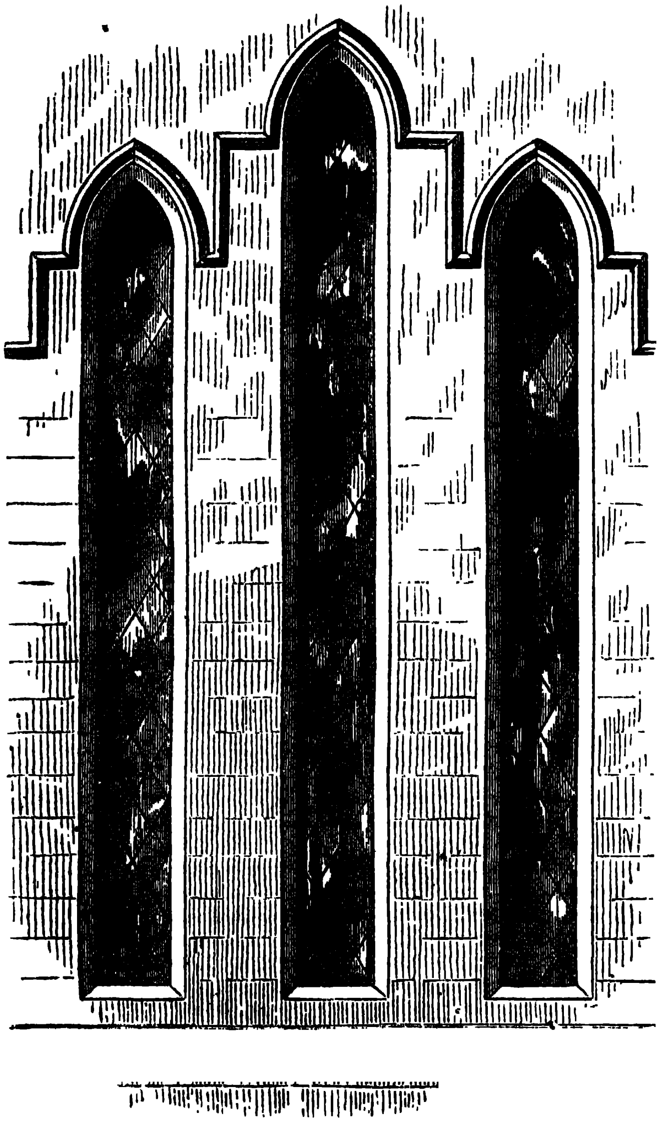

Fig. 476.—THREE-LIGHT WINDOW FROM STANTON HARCOURT, OXFORDSHIRE.

It has been shown in the previous lesson that when two lights were gathered under one dripstone, a blank space, known as the "tympanum," was left. But in process of time this space began to be pierced with another small light in the form of an ellipse, a circle, or trefoil, which at once relieved the blank space beneath the arch, and admitted more light. In Fig. 477 is given a window from Little Wenham Church, Suffolk, in which the space between the heads of the two lights is pierced by a diamond-like aperture, the two lower sides of which correspond with the inner sides of the arches, and the two upper sides being merely continuations of the outer sides, the same centres being used.

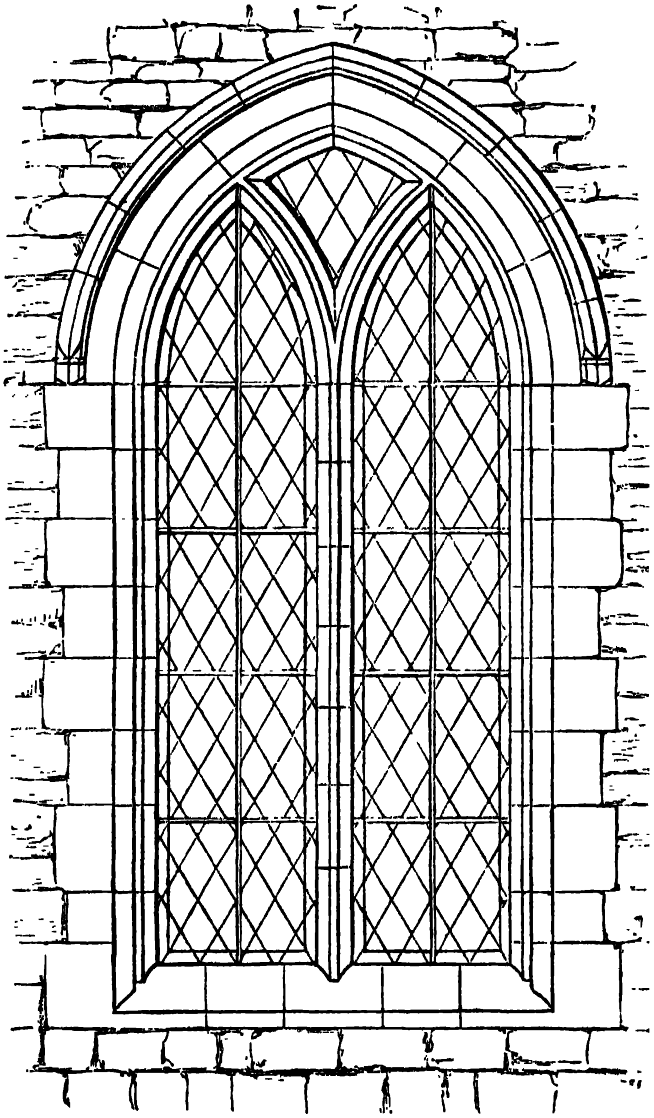

Fig. 477.—TWO-LIGHT WINDOW FROM LITTLE WENHAM CHURCH, SUFFOLK.

At Brownsover Church, Warwickshire, the upper corners of this aperture correspond with that of the outer arch or dripstone; but as this is not, as in the present instance, struck from the same centre as the heads of the lights, the effect is not so pleasant, presenting a broken, instead of a continuous curve, as shown in our illustration.

This elementary stage of ornamentation is called "*plate-tracery*."

A two-light window, with a lozenge form or quatrefoiled circle between the heads, was, as we have seen, the first decided step toward tracery. "It was," says Mr. Brandon, "a natural and easy advance to place two such windows in combination, and to pierce with a larger circle the space enclosed by a dripstone, forming a single arch above them both. Here appears, therefore, a four-light window with its geometrical tracery. Then one of the lights would, no less naturally, in some instances be suppressed; while, under circumstances of a contrary nature, a fifth or even a sixth light might be introduced, and in each of these cases alteration in the tracery must necessarily ensue. And, again, every such alteration would lead to the introduction of fresh variety, and thus illustrate the facility with which window tracery admits of change, even whilst fettered by geometric forms of beauty or consistency. In the first instance, in these early windows the cusping was for the most part restricted to the geometrical tracery, the heads of the lights remaining plain; but after a while a similar enrichment was introduced into the heads of the lights, to the great improvement of the entire composition."

In early cusped circles there is a distinctive peculiarity in the cusping. In these the foils are produced from the inner curve without rising at all into the chamfer. This style has been called *soffit* cusping, because it rises directly from the soffit of the arch, and not, as subsequently, from the chamfer or slope of the arch-side.

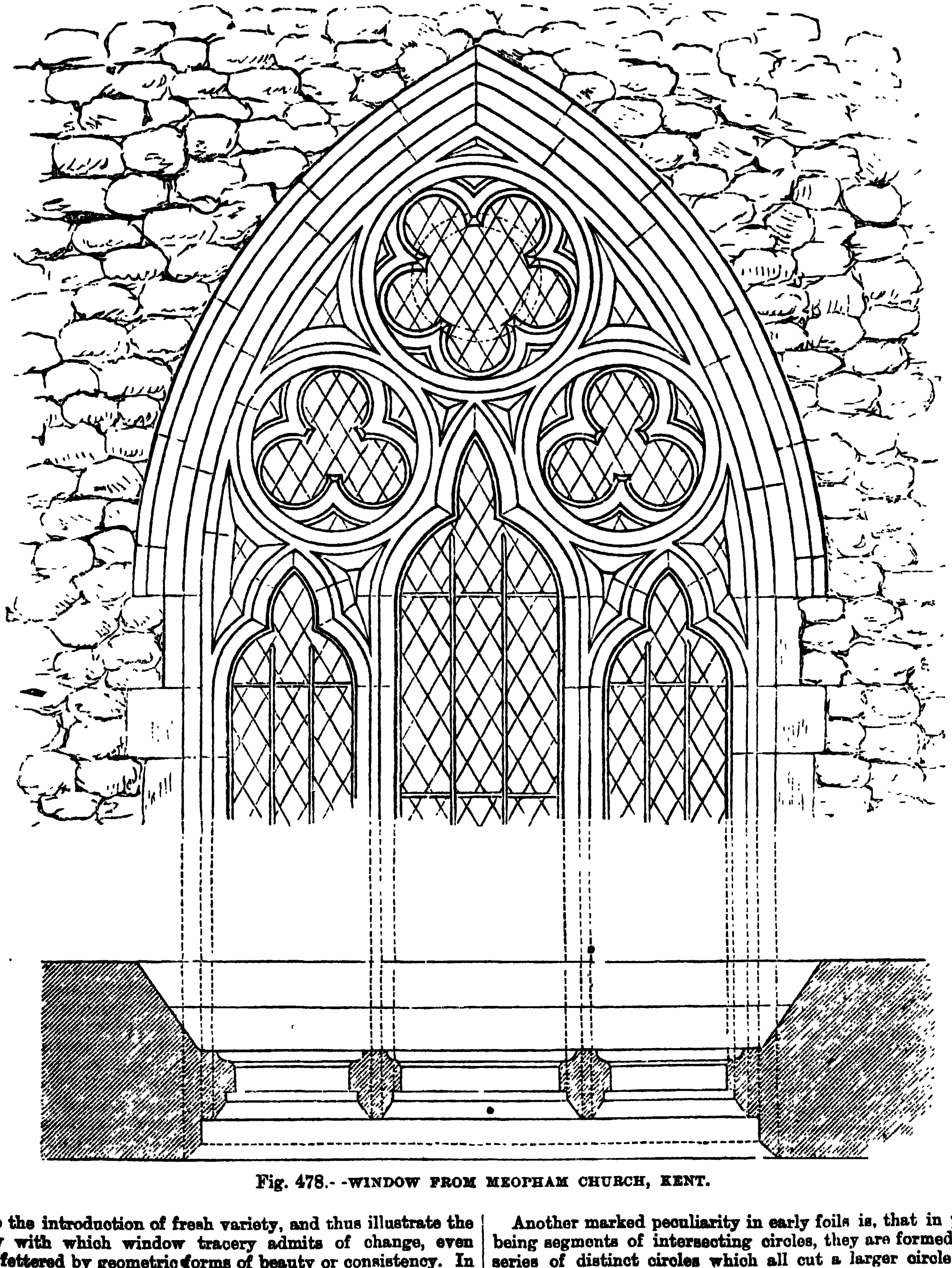

Fig. 478.—WINDOW FROM MEOPHAM CHURCH, KENT.

Another marked peculiarity in early foils is, that in place of being segments of intersecting circles, they are formed from a series of distinct circles which all cut a larger circle within. Tracery in the cusping of which any of these peculiarities occur, is invariably of an Early English when not actually of a Transitional character. The window from Meopham Church, Kent (Fig. 478), illustrates this early cusping.

It has been shown that the first advance towards the development of tracery was caused by the tympanum being pierced with an aperture in the form of a circle, trefoil, lozenge, etc., and that to this the name of plate-tracery had been applied. The system shown in the present example is characterised by the name "bar-tracery" in contradistinction to plate-tracery, illustrated in the previous figure, the patterns of the openings appearing to be formed by the intersection of various bars. This latter form arose naturally enough from the former by the multiplication of the piercings or apertures, till at last the plate disappeared, excepting such parts as were required to separate the openings and to connect the various parts.

In copying this example the student is advised to draw the plan first—not necessarily to the same scale; in fact, it would afford better practice to work to a larger scale, say 1 inch to the foot. The plan having been completed, the external form of the elevation and the mullions should be projected from it. The mullions develop into the tracery bars. The narrow, flat edges of the tracery—*i.e.*, those parts which form the plane of the whole front of the window—should next be drawn. The rest of the construction will be easily followed from the illustration.

Circular or rose-windows (called also wheel-windows and marigold-windows) are not unfrequent at this period, and are divided into compartments by slender shafts with capitals radiating from the centre, and sustaining at the circumference small arches usually trefoiled. Windows of triangular shape are also found, as well as a peculiar sort of window in the form of what is called the "vesica piscis;"[*] these are small, and are placed in subordinate positions, as in the gables or clerestories of parish churches. Beverley Minster, York, and Lincoln have circular windows of this style, peculiarly fine in character. The marigold-window in the south transept at York is also extremely rich; and there are the remains of a beautiful window of this kind in the front of the ruin of Valle Crucis Abbey, Llangollen, North Wales, already referred to.

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[*] *Vesica piscis.*—A figure frequently used in Early English and Gothic architecture. Generally the form is something like an ellipse, but pointed at both ends. It is formed by the intersection of two arcs of equal circles, and is somewhat similar in outline to a fish—hence its name. This form is sometimes given to the *aureola*, or nimbus of glory, in which representations of saints are enclosed.

CHEMISTRY APPLIED TO THE ARTS.—XIV.

BY GEORGE GLADSTONE, F.C.S.

GLASS-MAKING (*continued*).

In the last article we considered the manufacture of glass vessels, from the commonest bottles up to the ornamental cut ware. We have now to deal with the various kinds of glass which are used in the form of flat sheets. These are divisible into three principal classes—crown, sheet, and plate glass. They will be taken in order.

Crown glass was almost exclusively manufactured in this country until a comparatively recent period. It generally consists of silica, soda, and lime; with a little binoxide of manganese and arsenic to neutralise the effect of any oxide of iron or other impurities that may be present in the materials employed. The proportion of the several ingredients varies considerably in different works, and even at different times in the same works; but the following may be taken as about an average:—Sand, 500 lbs.; chalk, 150 lbs.; carbonate and sulphate of soda, 175 lbs.; cullet, 450 lbs. Sulphate of soda has the advantage over the carbonate of being cheaper and more easily worked, but it does not yield so colourless a glass; and therefore the use of the one or the other, or the relative proportions of the two, are governed by the quality of glass that may be desired.

The materials are mixed together and put into a pot similar to that described in the last article as used in making bottle-glass, except that a ring of clay is first put at the bottom of the pot. During the melting this rises to the surface, having a lighter specific gravity than the metal, and its presence there serves to reduce the space which it is necessary to keep clear of impurities during the manufacturing process. The pipe and the punty, as before, are the principal tools used. The workman gathers upon the end of his pipe, in successive dips, about 9 lbs. weight of metal, which he rolls upon his table or "marver" until it assumes a conical form, the apex of the cone being the bullion point. While continuing to roll it on the marver, a boy blows down the pipe, and it is heated and blown alternately until it attains the size of a glass globe. It is again heated at the furnace-hole and rotated rapidly, which causes the globe to flatten at what a geographer would call the poles, and widen out greatly at the equator. The next workman then takes it upon the punty, on the knob of which is a little hot metal fresh from the pot, which he applies to the bullion point; it adheres immediately, and then the pipe is cut off on the opposite side with a piece of cold iron, leaving, of course, a small hole where the nose of the pipe was. It is taken without a moment's delay to the flashing furnace, which is kept up at a great heat; and in front of this intense fire it is rapidly rotated until the side in which is the nose-hole gradually melts and extends, until at length it can no longer resist the centrifugal force, and bursts open, forming a flat circular disk of glass about 60 inches in diameter. Still twirling the punty, the glass is removed from the fire, and as soon as it is cool enough to retain its shape it is detached from the iron rod and taken to the annealing oven, where it remains one or two days.

A well-manufactured table should be very even in thickness, except, of course, in the centre, which is the bullion point or bull's-eye. There are generally, however, some slight indications of the way in which it is made, as window-panes will often be seen to contain striæ or markings which form segments of circles having a common centre; these are objectionable, as they slightly distort the objects seen through them. It is liable, like other glass, to accidental impurities in the metal, and also to the presence of bubbles, the latter generally arising from insufficient melting. In crown glass the bubbles are, moreover, more conspicuous than in plate, as they are drawn out and flattened by the rotatory action, till they present ultimately the appearance of large flattened disks. All these defects more or less detract from the value of the glass, the best being about three times the value of the commonest; and in cutting it for the market considerable judgment has to be exercised by the cutter, so as to secure wherever possible a piece that shall rank among the upper qualities. The table is only cut into two portions: the one which contains the bull's-eye being, of course, larger than the other.

Sheet glass works have only been established, or rather re-established, in this country within the last forty years; and in them the same materials are employed as those just described for making crown glass. The difference consists in the mode of manipulation. It will be sufficiently evident that a circular plate of glass of 60, or at the most 70, inches in diameter, and which has a bull's-eye in the centre, cannot possibly be cut so as to yield a large square; and that it will not, therefore, suit modern ideas of glazing windows, and still less of shop-fronts. The making of sheet glass, which had for a long time been superseded by the crown (partly, perhaps, because of the more brilliant surface of the latter), has now, therefore, been revived.

The workman takes a lump of metal upon the end of his pipe, as in the former process, and blows it upon a hollowed block of wood instead of a table, so as to limit the hollow ball to a certain diameter. The wood is preserved from being burnt by pouring water upon it, and the metal being at that time sufficiently hot to convert the water into steam immediately, the glass is not rendered brittle by its presence. In front of each working-hole of the furnace is a wooden platform, with a pit below, and upon this platform the blower now stands, and, by a succession of re-heatings, blowings, and swings round of the metal in a vertical plane, the hollow ball gradually becomes drawn out into a long cylinder. The extreme end of it opposite to the pipe will naturally be thinner than the rest; this part is then made very hot, and is burst open by the expansion of the internal air through the heat, the end of the pipe being closed to prevent its escape in that direction. The edge of the orifice thus caused is trimmed with the scissors, and the aperture widened with the tongs until the cylinder is of uniform diameter throughout. It is then cut off at the other end, by passing a hot iron round it, and dropping some cold water on the heated line. It thus forms a long glass drum, open at both ends.

This drum has now to be split and flattened. The first is partially done by taking a diamond, and drawing a straight line longitudinally along the inner surface of the glass. In this condition it passes to the flattener. By him it is laid upon a smooth plate, with the cracked side uppermost, and heated at the flattening furnace, when it opens along the line where the diamond has passed, and gradually sinks down upon the plate as a flat sheet of glass. The flattening is, however, expedited by passing an iron ruler over it as soon as it has commenced to gape open; and when quite flat a rod with a smooth block of wood at the end of it is employed wherewith to rub the surface so as to take out any roughness or waviness which may remain. It then only requires annealing, and the sheet is finished.

Glass thus made is free from some of the defects incident to the crown process; but in the flattening and rubbing it loses the fine smooth surface which the other has, and though largely used for the glazing of windows, its appearance is not altogether satisfactory. An economical, and at the same time efficient way of grinding and polishing the sheets has, however, been discovered, so that now it may be had with as fine a surface as plate glass, and it is used as a substitute for the latter in the glazing of the best houses. The sheet of glass is pressed upon a damp piece of soft leather stretched on a flat frame, which is all that is requisite to make it adhere firmly. Two of these are then laid face to face, and are rubbed together by machinery, sand and water being made to flow between them. They thus grind and polish each other; and as soon as the one surface is done, they are turned, and the process is repeated.

The usual size of a sheet is 47 inches by 32; but for special purposes larger sizes are sometimes made. Sheets of large dimensions and corresponding thickness are, however, very trying to the strength of the workmen who have to make the cylinders.

The International Exhibition building of 1851 was glazed with the unpolished sheet glass; each cylinder was made to produce a sheet measuring 49 by 30 inches, which was afterwards cut lengthways into three equal parts. Of these about 300,000 were required for the purpose, the whole of which were manufactured by one firm, the Messrs. Chance, of Birmingham.

Plate glass is made by a comparatively simple process; but as the main object of making it is to obtain very large sizes, which must have a corresponding thickness, very great care is necessary at every step, lest when finished it should be found to contain flaws or have too much colour. A plate to be used as a mirror should indeed be absolutely free from any blemish; and if it has a slight greenish tinge, it gives, after being silvered, a very unpleasant tint to the objects reflected by it.

In the first place, the very best materials must be used, and the sand should be well washed to remove any accidental impurities. The following are good proportions:—

Best white sand	42·5	per cent.
Soda salt, 40 per cent. of alkali . .	26·0	„
Caustic lime	5·0	„
Nitrate of potash	1·5	„
Cullet	25·0	„
	100·0	

These will be seen to differ essentially from flint glass, not only in the absence of lead salts, but also in the use of soda principally instead of potash. This causes all plate glass to be more or less greenish, but at the same time it renders the metal more fluid, which is a matter of some importance in the casting, and it also facilitates the separation of any impurities that there may be in it. By increasing the quantity of potash, a more colourless glass would be obtained; but this alkali has such a faculty of absorbing water that glass made with an excess of it will become sweaty, and cannot be kept clean and bright.

The ingredients are melted in the open-mouthed pots already described, and when ready for use the casting-pot is rapidly withdrawn from the furnace by a travelling crane, and brought over the table. This is a large sheet of iron resting on a frame which runs on wheels; the iron top is highly polished, and has a movable strip of metal on each side, which is varied according to the intended thickness of the glass. Before using it, the surface of the table has to be heated, which is generally done by sprinkling hot coals upon it, after which it is wiped quite clean.

The metal, after having been kept at the fullest heat until all the bubbles have escaped, is allowed to cool down a little till it commences to lose its liquidity, and to become slightly viscid. It is then (after being skimmed) ready for pouring out upon the table. As soon as that is done, a heavy metal roller is passed over it, and the glass is thus rolled out into a flat sheet of the thickness corresponding to that of the side strips above described. Any excess of metal falls over the end of the table which is left unprotected. This, while still soft, is bent upwards in the form of a flange, so as to be free of the table for the next operation.

The whole is then wheeled to the door of the annealing oven, and the sheet of glass is pushed in by pressure on the flange at the farther end; there it remains for some days, during which the temperature is gradually reduced from a dull red heat, at which it was at first, until it becomes cool.

When the annealing is complete the plates have to be carefully examined for flaws, and are cut into the largest squares that can be obtained without including any of these. They then pass to the grinding and polishing house. A large plate is firmly fixed with plaster of Paris on the top of the grinding-bench; a small one is likewise fixed on the under side of a heavy travelling table, to which a rotatory and at the same time oscillating motion is given by the machine with which it is connected. Thus one plate is made to grind the other, with the help of fine sand or ground flint and water, which is thrown between them. Both sides are ground in this way. They have then to undergo a succession of grindings by hand, with emery powder of gradually increasing fineness, so as to reduce the coarseness of the granulation caused by the machine-grinding, and gradually to prepare it to receive a polish. Women and girls generally do this best, as it must be done lightly; and their hands more readily detect any grittiness in the emery powder, which has specially to be guarded against.

The polishing is done with a woollen cushion, and a composition containing a little of the hydrated oxide of iron; the cushion is attached to a handle which is usually driven by machinery, as that does the work more regularly and systematically than hand labour, and produces in consequence a more even result.

When the plates were in their rough state many minor flaws might pass undetected, which unfortunately cannot escape notice when the glass has received its fine polished surface. They must needs, therefore, be re-examined, and the defective portions cut away. The pieces which are most free from colour, waviness, and bubbles, are selected for the making of mirrors; the rest being used for glazing or any other purpose of minor importance.

The very general employment of plate glass in shop-fronts has given a great impetus to the manufacture; but, besides the home consumption, it is exported to other parts of the world in considerable quantity, as there are no plate glass works of importance yet established either in the United States of America or in our own colonies.

THE LATHE.—IV.

By Henry Northcott.

ADVANTAGES OF DOUBLE GEARING FOR LATHES.

The usefulness of the double gearing is considerable, for though simple, it adds a great deal to the power and use of a lathe. It is not always made in the manner shown in our last paper, but this arrangement illustrates the principle of the most approved mode of application. In some cases the wheels, instead of sliding towards and away from each other by diminishing or increasing the distance between the axis, are thrown into gear and out of gear by the back axis sliding lengthwise in its bearings a distance rather in excess of the width of the wheels; but in the best lathes the back shaft is a socket mounted on a central spindle, which latter is carried by two excentrics, and with this arrangement the wheels are caused to approach and gear with each other or recede by moving round the excentrics. This latter plan is probably the neatest and most complete, but the second is, I think, the simplest. Both plans are in very frequent use, and will be illustrated in some of the complete lathes to be shortly described.

Although this double gearing allows of a very great reduction of the speed of the lathe-spindle and corresponding increase in its power of overcoming resistance, a still greater reduction of speed and increase of power are required for some large lathes, and consequently these lathes are sometimes furnished with treble and quadruple gearing of very great complexity and power. In most of these very powerful lathes the last pinion is caused to gear directly with a large wheel forming part of the disc or circular plate on the lathe-spindle nose which carries the work. The object of this is that the great torsional strain which would otherwise be transmitted through the lathe-spindle itself, and which would consequently have to be made very strong to enable it to safely transmit such strain, shall be communicated directly to the face-plate, and applied as near as possible to the spot where the resistance of the tool's cut has to be overcome. Such powerful and complicated trains of wheels are chiefly necessary for lathes that are designed for turning very large surfaces, and which lathes are hence called surfacing lathes.

I am not aware who was the originator of the double gearing, but it is a most valuable invention. In its earlier shape it was applied something in this way:—An ordinary lathe face-plate was furnished with a wheel which was attached to its back, and a small pinion was fastened at the back of the lathe-head by a bracket bolted to the lathe head-stock. This pinion was arranged to gear with the wheel on the face-plate when heavy work had to be turned in the lathe, or it could be removed from gear when the slow motion was not required. The small pinion received its motion not from the lathe-pulley in any way, but from the overhead shaft driven by a separate belt. Now, this arrangement was quite as efficient as any of those since introduced in reducing the speed of the work within the range of a simple wheel and pinion, but the plan necessitated a separate belt, which was rather in the way when the ordinary motion was required. A lathe fitted with this kind of gearing I have seen, but have no idea of its age. When I saw it, it had for some time been consigned to that depository for all useless lumber known in engineering establishments as the "scrap heap." Many rude forms of slow-motion gear have, doubtless, been devised in the early days of the modern lathe, but most of them, probably, have never been known outside the workshop where they were originated; and they may be classed with the numberless little ingenuities and improvements that are continually being called into existence by the cunning brain of the clever mechanic, and which inventions form but a very small part of his weekly labours.

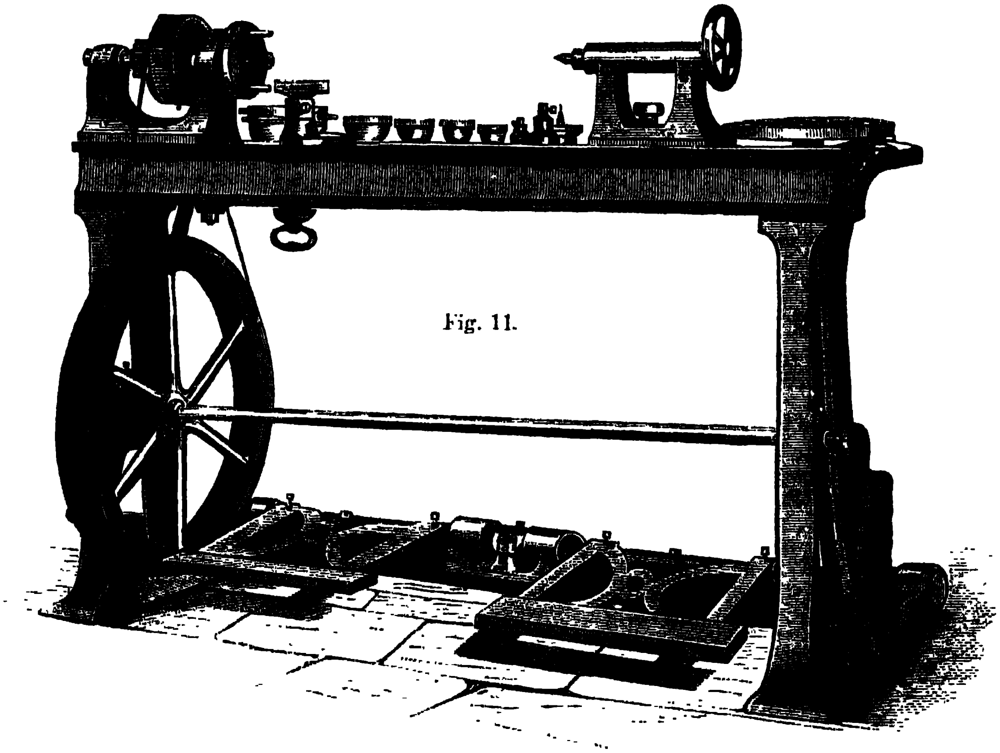


Fig. 11.

The double gear as now employed leaves very little to be desired; it is simple, thoroughly efficient, is easily put into and out of use, and when not wanted, it is not in the way or inconvenient. For small fast-running lathes the wheels should be machine cut, that is, their teeth should be cut out of the solid metal by a wheel-cutting machine, as this causes them to run smoothly and with little noise. It is also a very common practice to make the wheels with oblique teeth instead of the usual square teeth, and no doubt such wheels are well adapted to the purpose, as they gear with each other evenly, and run at a high speed with very little tremor or noise. For large lathes the gear-wheels are ordinary well-moulded spur-wheels, chucked with reference chiefly to the teeth, and turned up true upon the face and sides of the toothed rim. Such wheels are sufficiently accurate for the purpose, and as they do not run at any great speed they do not make much noise in working. The most usual mode of connecting the large wheel on the lathe-spindle with the cone-pulley, is by a sliding screw or bolt passing through the spur-wheel, and having a T-head inside and a washer and nut on the outside of the wheel. The cone-pulley is accurately mounted upon the lathe-spindle, and is cast with a flange on the side abutting against the spur-wheel, and in this flange is cut one or more spaces for receiving the T-head of the sliding bolt. When the spindle has to run at the fast speed the wheel and pulley are connected by sliding the small bolt outwards until the head of the bolt falls into the space cut in the pulley-flange, and in this position the bolt is kept by tightening the nut on its outside extremity. When the spindle is wanted to rotate at a slow speed, and independently of the lathe-pulley, the nut is loosened and the bolt slid outside of the space cut in the flange, when the nut is again tightened. For light fast-running lathes using this mode of connection, it is as well to balance the momentum of the sliding bolt by a counterweight cast on the spur-wheel on the other side of its axis. If this is not done the lathe will shake a great deal at high speed, and cause undue wear of the bearings of the lathe-spindle, as well as danger to slight and accurate work. In some lathes the connection at will between the wheel and pulley is formed by a screw passing through the plate of the wheel, and screwing into the metal of the pulley. This screw is removed altogether when the slow-motion gear is used, and at such times the screw is very likely to be misplaced and lost; altogether, such a connection is not to be recommended. Another mode of connection much better adapted to light lathes than either of the previous is that of frictional contact, caused by jamming the pulley against the wheel by means of a large nut and screw-thread upon the spindle at the other side of the cone-pulley and small pinion. The connection is made by screwing this nut tight up against the pinion, thus forcing the pulley against the spur-wheel; and the two are disconnected by screwing the nut backwards against a collar on the lathe-spindle, so that the pulley, being no longer jammed between the nut and wheel, is enabled to rotate freely upon its spindle. This latter connection is very easily made and unmade, and the balance of the moving parts is not affected in any way. The reader knowing a little of mechanics will probably ask why a series of wheels are used to reduce the speed and increase the power, when a single wheel with an endless screw gearing into it would do so with much less complication, and this obvious simplification appears so plausible that it has been many times tried. The friction, however, of the worm and worm-wheel is much greater than that of the train of wheels, and absorbs so much of the driving power, that the latter mechanism is for such purposes almost always used in preference, notwithstanding the simplicity of the former. This is not, however, the case when a reduction of speed is the only object to be attained, and very little resistance has to be overcome.

The power a man can exert in treading in the manner required to give motion to a lathe is after all but very little, and although this may be multiplied by means of the mechanism just described, the range of such mechanism is much too small for the purposes of the mechanical engineer. A man on ordinary work would probably exert in treading a lathe a force equal to about 2,000 to 3,000 pounds raised one foot high in the minute. A horse-power is invariably assumed to be equal to 33,000 lbs. raised the same height in the same time, so that in treading a lathe a man only exerts a force equivalent to 33,000 ÷ 3,000 = one-eleventh of a horse-power. This force aided by the double gear is enough for ordinary light metal turning, but when heavier work has to be performed it becomes necessary to employ either more men or some other motive power, such as that derived from a water-wheel or the steam-engine. When light work is the rule and heavy work the exception, and steam-power not at hand, it is in some cases advisable to employ two or more men; but in other cases steam or water power is in every way cheaper and more convenient. When men are employed they can either drive the lathe by means of a large wheel, as already described, or they can exert their strength upon the lathe-treadle. When the treadle is used in the ordinary manner, it is plain that the force can only be applied during the downward stroke of the treadle-board, and if much power be applied a very heavy fly-wheel must be employed to obtain the momentum necessary for carrying the crank onwards during the remainder of the stroke until the pressure can again be put upon the treadle-board. To obviate this necessity, and allow of the more effective employment of two or more men, lathes are constructed with two or more treadles, and the treadles are so arranged that one shall be rising whilst the other is being pressed downwards. Fig. 11 illustrates a lathe having such means of receiving the driving power, patented some years ago by Messrs. W. Muir and Co., Manchester. The manner in which the treadles are arranged is plain from the figure. The lathe shown has double treadles and cranks, and the two are connected by means of endless chains passing over trucks or small rollers with a view of lessening friction. This lathe has cast-iron standards and cast-iron bed. The driving-pulleys are grooved, and the motion is communicated by a gut. It also has double gearing, and an internal screw-puppet, and is altogether a plain and serviceable lathe.

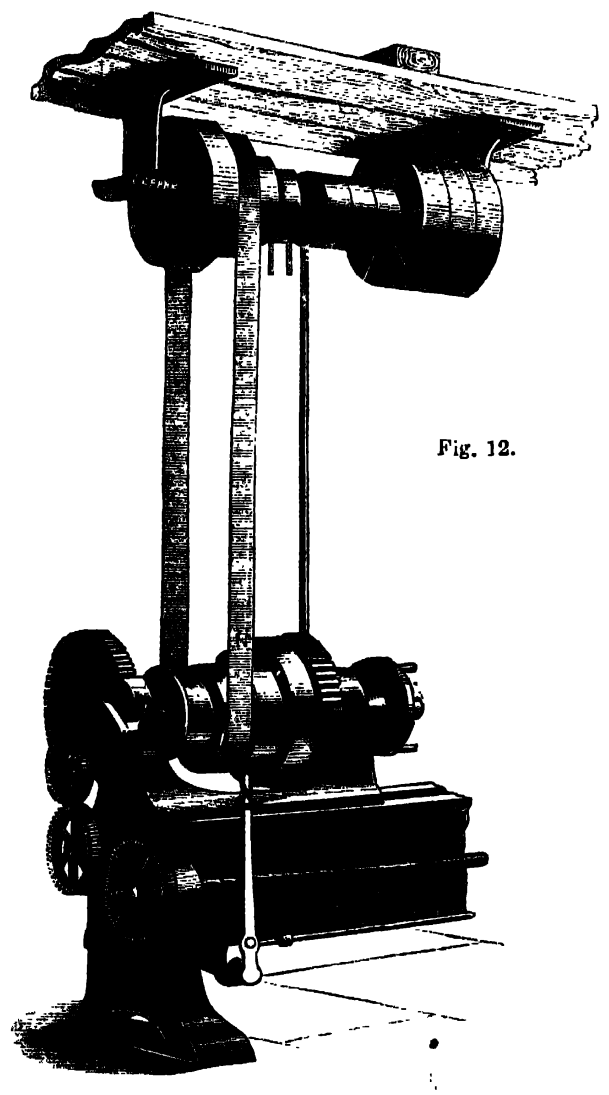


Fig. 12.

Gut-driving bands are used only for light lathes, for which they are extremely well suited. Heavier lathes, requiring more power, are driven generally by means of a flat leather belt, and the lathe-pulleys are also made flat instead of being grooved. Leather belts are strong and durable; they run quite noiselessly, and can be made to transmit any amount of power by having them of a suitable width. They should, however, always be well stretched before being cut to the required length, as otherwise it will be many months before a new lathe-belt will cease to give trouble by becoming too slack to transmit the power, and a good deal of the belt will eventually have to be cut off. The ends forming the joint should be cut rather thinner, so that the joint should not be too thick and clumsy, and if a little oil and powdered resin be thrown between the surface of the belt and pulley, it will hasten the production of a good working surface to the belt. This is a great desideratum, as new belts, being hard and stiff, cause a great deal of trouble by slipping.

When lathes are driven by steam, there is usually a main driving-shaft running through the workshop, and from this the power is transmitted to an intermediate shaft placed a few feet over the lathe-pulley. This intermediate shaft is driven at a constant speed by a leather belt; but it also carries a cone or stepped pulley corresponding to that on the lathe-spindle. The position of this countershaft and the mode of driving the lathe are shown plainly by Fig. 12, which scarcely needs any further description. In the figure the countershaft is shown with two sets of pulleys, in all six pulleys besides the cone pulley. It is therefore necessary to say that for driving an ordinary plain lathe, only one set of two pulleys is required, and the uses of the remaining pulleys will be shown hereafter. Of the two pulleys used, one only is fastened to the countershaft; the second is simply placed upon it without being keyed to it, so that the shaft and pulley may rotate quite independent of each other. The fixed pulley is termed the "driving-pulley," the loose one is termed the "idle" pulley. The idle pulley is kept against the other by means of a collar on the countershaft. There is a third pulley on the main shaft of the workshop of a size depending upon the speed of the shaft and the required speed of the lathe. A leather belt, rather narrower than one of the countershaft pulleys, passes round the main driving-pulley and the countershaft-pulley. Suppose the main shaft to be running, the leather belt would obviously communicate the motion to the pulley of the countershaft upon which it was running. If the belt were upon the fast or driving-pulley of the intermediate shaft, the shaft itself and consequently the lathe would be rotated also; but if the belt were running upon the idle pulley, that pulley would alone rotate, and the countershaft and lathe remain still. This expedient of fast and loose pulleys is the one generally adopted for starting and stopping the lathe driven by any external motive power, a lever and slide with a fork embracing the belt being employed for transferring the belt from one pulley to the other. By this means the motion is gradually imparted to the lathe and work, and there is no injurious shock or strain given to any part, nor is the stopping or starting attended with any disagreeable noise.

BUILDERS' QUANTITIES AND MEASUREMENTS.—V.

BY E. WYNDHAM TARN, M.A.

ABSTRACT OF DIMENSIONS.

We shall now give an abstract of all the dimensions tabulated in the last lesson (page 58), so as to show how they are to be prepared for bringing into bill:—

ABSTRACT.

		Superficial.							
Concrete.	Cube brickwork. ft.	Add. 1 bk. ft.	Add. 1½ bk. ft.	Ddct. 1 bk. ft.	Ddct. 1½ bk. ft.	Superf. Asphalte. ft.	Superf. Tuck pointing. ft.	Runs.	Nos.
1 of lime to 6 of ballast. c. ft. c.yds. 27)426(15⅞ 27 156 135 21 6 in. concrete floor. Superf. ft. 9)446 49½ yds. 6 in. cement concrete. ft. 9)22 6 2½ yds. 9 in. ditto in walls, includg. use of apparatus. ft. 9)191 6 21¼ yds.	23 0	94 47 47 23 6 2850 164 126 980 6 108 94 3 47 2 4081 5 201 9 3879 8 2 3)7759 4 2586 5 838 0 rd. ft. 272)3424 5(12 160 272 704 544 160..........	23 6 47 23 6 987 14 32 6 1127 6 289 1 838 5 .Fence wall. ft. 292 6 2 3)585 195	72 114 9 15 201 9	59 29 19 6 118 2 63 5 289 1	86 1 bk. nogging. ft. 161 144 8 9)305 8 34 yds. ½ bk. trimmer. 10 6 7 6 18 0 Malm facing. ft. 9)808 5 89¾ yds. Malm cutter arch. ft. 76 8 1 bk. vault. ft. 9)66 6 7½ yds...	9)1006 112 yds. Flat jt. pointg. ft. 9)2077 231 yds. Splay. ft. 20 5 ½-inch tile, paving in cement. ft. 9)895 6 99½ yds. ... bk. on edge paving. ft. 9)35 9 4 yds.	I. hooping, 1½ × 1/16. ft. 3)1128 376 yds. W. I. chimney bar, 2½ × ½. 45 ft. Chamfer to brickwork. 31 ft. Double tile creasing. 32 ft. Extra to bk. on edge coping in cement 65 ft. 6-in. pipe drain. 60 ft. Chase for R. W. P. ft. 22 6	Flues cored. 6 Chy. pots. 6 Setting range. 1 Setting stoves 5 Beddg. and pointg. frames. 12 Air-bricks. 8 6-in. junction to drain. 3 6-in. bend. 2 6-in. syphon-trap. 1

The abstract is now ready for bringing into bill, which being the last process in the operation of taking out quantities, or of measuring work that has been executed, is not performed until the whole of the trades have been abstracted; we shall, therefore, place the bill at the end of this series of lessons, and then bring all the trades together into one bill.

TILER AND SLATER.

When tiles or slates are used as the covering for a roof, the measurement is nearly the same in every case, being taken by the square of 100 superficial feet. In measuring plain tiling, take the length along the eaves by the depth on the slope, with 6 inches over if there are dripping eaves, and 4 inches for other eaves. Measure the length of the valleys by a width of 1 foot, and add it to the superficial area; also take the length of all cuttings by 3 inches wide for a superficial measurement. Describe the width which the tiles show on the face, whether 3 or 4 inches, the kind of laths, nails, etc. Where there is a barge-board to the gable measure its length as run of heading. Flat roofs formed of plain tiles, of two or more courses in cement, are measured also by the square of 100 feet. Ornamental ridge tiling is taken by the foot run, and its character or pattern described, by a sketch in the margin of the bill; other ridge tiling or hip tiling is taken in the same way.

Ornamental or patent tiling is measured by the square, and described, or a sketch shown.

Pan-tiling is taken by the square, but no allowance is to be made for eaves; the gauge is stated, and whether laid dry or in mortar; also if pointed on the outside. Heading to gable-ends, ridges, hips, and valleys, filleting, etc., are taken by the foot run. Take the number of the hip-hooks and T-nails, including painting.

When a triangular piece of tiling or slating has to be measured, as in a hipped roof, take the length of the eaves by half the depth of the slope, measured at right angles to the line of the eaves.

There are several kinds of slates used for roofing purposes, and the quality must therefore be described; the measurement is the same as for tiling, by the square. The amount of lap, and the kind and size of nails used, must also be stated. In taking the width of the slating, allow an extra amount equal to the gauge of the slates, if laid double at the eaves. Slating is sometimes pointed on the under side with mortar, which is included with the superficial measurement, and must be described. Deduct all openings in the slating for dormers or chimneys, and measure all cutting, the length by six inches in width, adding it to the superficial measurement. Circular work can either be measured net and described, or an allowance of one-third extra can be made for it, and added to the plain work.

If slating is laid on asphalted felt, the felt is measured separately, by the square. Sawn slate hips and ridges are taken by the foot run. Slate slabs, when used as shelves, cisterns, steps, etc., are taken by the foot superficial, describing the thickness, and whether planed or rubbed. Grooving, moulding, rounding, etc., to sawn slate is taken at per foot run, describing the thickness.

The following dimensions will serve to illustrate the measurement of tilers' and slaters' works:—

2)	31 6 14 4	903 0	Plain tiling, showing 4 inches, on double fir laths and wrought nails.
	15 0 7 4	110 0	Add hip.
	19 6 1 0	19 6	Add valley.
		1032 6	
2)	14 0	28 0	Heading to barge.
	31 6	31 6	Ornamental ridge tiling.
	9 6 6 6	61 9	Flat roof of 2 courses plain tiles in cement.
2)	31 6 14 0	882 0	Pan-tiling to a 10-inch gauge, bedded in mortar, and pointed.
2)	14 0	28 0	Heading to barge.
	23 0	28 0	Cement filleting.
	45 0	45 0	Hip and ridge tiles in cement.

No. Hip-hooks and painting.

2) 31 6 14 8	924 0	Countess slating, 2½ inch lap, two 1½-inch copper nails to each slate, and pointing the underside.
2) 18 0 1 0	36 0	Add for cutting to hips and valleys.
15 0 6	7 6	Ditto ditto round chimney.
	967 6	
6 0 1 6	9 0	Ddct. opening for chimney-stack.
5 0 3 0	15 0	Ddct. skylight.
	943 6	
45 0	45 0	Sawn slate hip and ridge, and fixing with white lead and copper screws.
2) 31 6 14 8	924 0	Asphalted felt laid under slates.
24 0 1 3	30 0	¾-inch sawn slate shelf, planed.
24 0	24 0	Rounded nosing to ¾ shelf.

ABSTRACT.

Superf.
Plain tiling, 4 inch on face, double fir laths, wrot. nls.
ft.
100)1032 6
10⅓ sqrs.

Superf.
Flat roof of 2 courses plain tiles in cement.
ft.
61 9

Run.
Heading to barge.
ft.
28 0

Ornl. ridge tiling in cement.
ft.
31 6

Superf.
Pantiling, 10-inch gauge, in mortar and pointed.
ft.
100)88[illegible] 0
8[illegible] sqrs.

Run.
Heading to barge.
ft.
28 0

Cement filleting.
ft.
28 0

Hip and ridge tile in cement.
ft.
45 0

No. 2 hip-hooks and painting.

Superf.
Countess slating, 2½ lap, two 1½ inch copper nls., and pointing underside.
ft.
100)943 6
9 sqrs. 44 ft.

¾-inch sawn slate shelf planed.
ft.
30 0

Asphalted felt.
ft.
100)924
9¼ sqrs.

Run.
Sawn slate hip and ridge, fixed with white lead & copper screws.
45 ft.

Rounded nosing to ¾-inch shelf.
24 ft.

OPTICAL INSTRUMENTS.—XVI.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

Gasometers and Gasholders.—As the lime-light is employed by the photographic enlarger as well as the lantern exhibitor, the special requirements of each must be considered when selecting an outfit. A lantern exhibitor in the course of a couple of hours completely uses up the six or eight cubic feet his bags are stored with; not so the photographer, who often only brings his apparatus into use for a few minutes, and often with many days' interval. Now it is well known that, if the gases are kept in bags for several days, both oxygen and hydrogen will be found deteriorated in quality, through atmospheric air having passed, by an endos- and exos-motic action, through the pores of the cloth and mixed with the contained gas. Again, as the gases are seldom rendered chemically pure, if they are left in the bags for any time the india-rubber cloth is attacked, and after a little time is rendered rotten, by their corrosive action, especially in the case of oxygen, which seldom comes over without traces of free chlorine. Metal reservoirs are, therefore, better suited for the work of the photographer, as portability is not an essential, especially as they can be put into a neat and compact form that stands in a fixed position ever ready for use. But there is still another class of operators to whom gasometers or gasholders would be preferable to gas-bags, namely, those who reside abroad, for the reason that, in very hot or very cold climates, india-rubber cloth rapidly deteriorates in quality, or cracks through being hardened by a continuous low temperature. Again, in places infested by cockroaches, those invertebrate gourmands manifest such an extreme affection for gas-bags, that if they get the chance of making their acquaintance they never fail to "make them one of themselves."

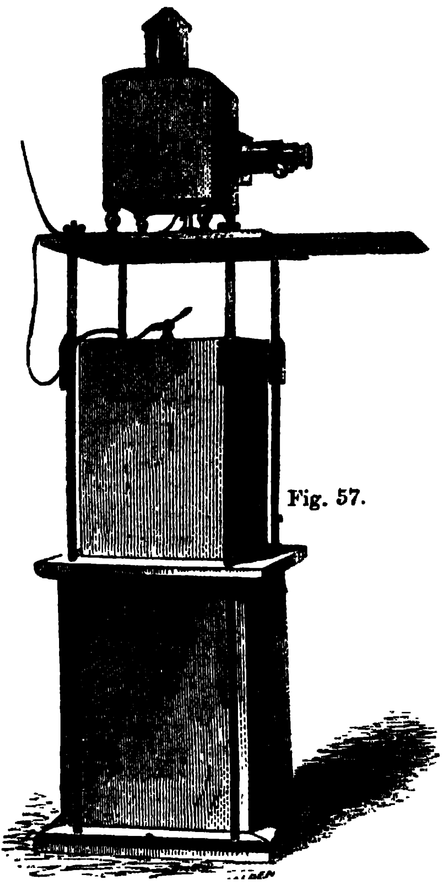


Fig. 57.

In a paper read before the Society of Arts in 1863 (just after the close of the International Exhibition, where I displayed the apparatus referred to), I described and figured a form of gasometer here reproduced (Fig. 57), which would be found extremely useful in a photographer's enlarging room, as it not only stores the oxygen for an oxy-calcium jet, but forms a solid support for the enlarging lantern. This I originally designed for a professor's lecture-room, where only small quantities of oxygen were required at a time, for the display of an occasional diagram in illustrating a course of lectures, and to avoid the daily or frequent production of oxygen.

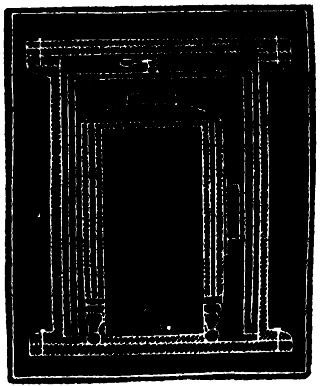
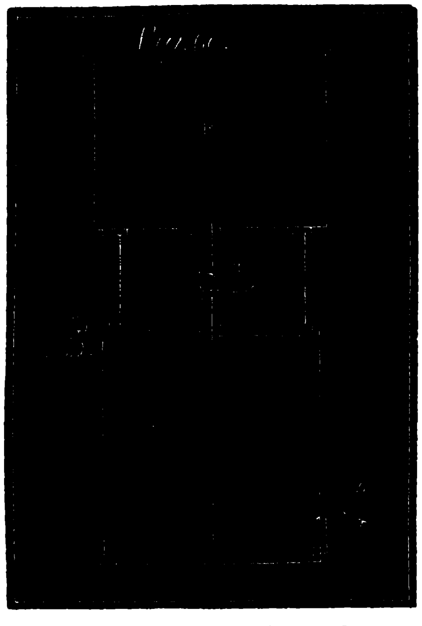


Fig. 58.

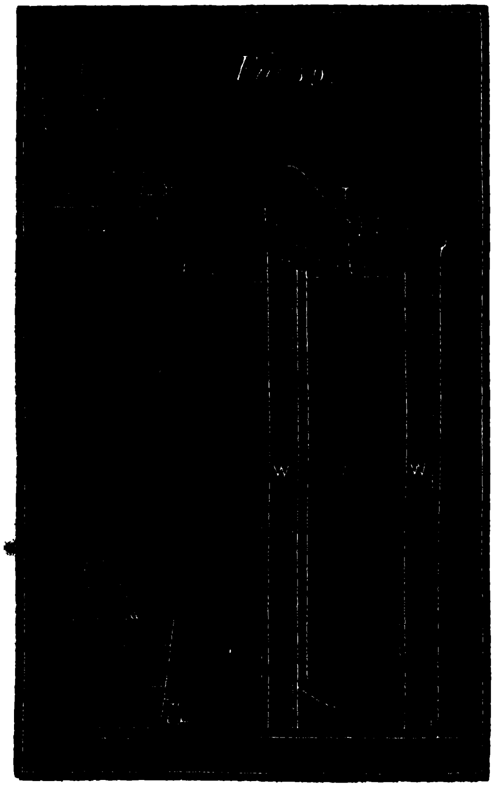
Fig. 58 shows how I contrived this arrangement, so that the lantern could be packed in the body of the gasometer for travelling, if necessary, a matter of consideration for the wants of the Indian colleges, where the apparatus is sent from one professor to another, at distant stations.

When unpacked and arranged for use, as shown in Fig. 57, it will be seen the "bell" that holds the gas is square instead of cylindrical, the form in which gasometers are usually made, slides up and down, in a double casing, shown in section in Fig. 58, that is filled with water, to form an air-tight water-joint for the rim of the bell, and to reduce the bulk of water required for this purpose to a minimum. The bell and water reservoir are both made of sheet zinc, the reservoir being strengthened and protected by an outer casing of wood that forms a packing-case to the arrangement (as shown in Fig. 58). Four iron rods fit into wooden fillets; on to the rods the flap lid of the packing-case is screwed, to form a table for lantern and apparatus. At the top corner of each rod a pulley-wheel is inserted, over which cords attached to the four corners of the bell pass; to the ends of each cord counterpoise weights are suspended to keep the bell from "wobbling." A stop-cock is inserted in the middle of the top of the bell by which the gas is introduced, as well as drawn off. Before filling a gasometer the bell must be pushed down till its top comes in contact with the water that covers the roof of the reservoir, so that all air may be first driven out. When in work the necessary weights are placed on the top of the bell. When packed the four rods are strapped together, and the whole packs into a space of 15 inches square by 24 inches in height.

In the arrangements for storing gas, previously described (with the exception of the self-acting hydrogen generator), pressure has been obtained by the employment of iron weights, etc. I shall now proceed to discuss the merits of gasholders wherein water pressure is used.



The first arrangement I shall describe consists of an inner closed chamber, O (Fig. 59), that receives the oxygen gas, placed within, and communicating by openings at the bottom with an outer one of equal capacity open to the air. At starting, the inner chamber, O, is filled with water, which is displaced on introducing the gas through the tube I, being driven into the outer chamber, and carried away by a waste-pipe at P, to a pail or sink. The outer chamber, W, remains full of water. The height of this apparatus should be about five feet, and the diameter of the inner chamber one foot. On connecting the inner chamber with the jet, and opening the tap T, the water passes from the outer to the inner chamber, and rising, drives out the oxygen under a pressure which, however, is constantly diminishing. Of course this action would come to a stop when the water finds its level, unless the water previously displaced can be returned to the outer chamber; and this may be effected by putting a pail, filled with water, on a shelf placed at a suitable height, and letting the water flow into the outer chambers of the gasometer, till both compartments are again filled, and the inner one emptied of gas. By proper adjustment of the flow, by means of a small ball-cock arrangement, a constant pressure could be obtained.



It is a question, however, whether a Pepys' gasholder, modified so as to make it portable, would not be a preferable arrangement, especially for replacing gas-bags in foreign climates. This likewise consists of two chambers, as shown in Fig. 60, only placed over instead of being parallel with each other. The compartment G is filled with water from the reservoir, R, till it runs over at the tap, S, which is then closed, as is also the tap, T. The delivery-tube of the gas-generating apparatus is introduced into a tubular opening at A, till the gasholder is filled; it is then removed, and A is closed with a screw-cap fitted with a washer. The reservoir, R, is again filled with the water displaced from G, the tap, T, is opened, and on the stop-cock, S, being opened the gas is driven out under pressure. The amount of pressure may be varied according to the height the water reservoir, R, is placed above the bottom of the gasholder, G, but a tube three feet in height would give sufficient for all ordinary purposes. Whatever be the size or shape of a gasholder, a column of water 33 feet in height would give a pressure of 15 lbs. on the square inch. The gasholder represented in Fig. 60 is made portable for travelling by arranging the diameter of G to be somewhat less than that of R, so that the former can pack inside the latter when the taps, S, T, and the tube, A, are unscrewed and the two chambers disconnected by unscrewing the three pillars that support them one above the other when fitted up for use.

The secret of safe manipulation does not rest so much in the construction of the jets employed for the lime-light as in a perfect perception on the part of the operator that atmospheric air must never be allowed to mix with the gases: therefore both generators and gas-bags, etc., must be perfectly emptied of air before commencing work, as previously described; that pressure must be constantly kept upon the gas-bags, gasometers, or gasholders, before their taps are opened, and during the whole time the gases are ignited at the nozzle of the jets; that when the two gases are employed with the oxy-hydrogen jet, an equal pressure must be kept upon each reservoir, for if the pressure becomes unequal, either through having a weight on one receptacle and not on the other, or through having a hundredweight on one and a half-hundredweight on the other, or setting up unequal pressure through unequal leverage by an improper distribution of the weights, or by one pair of pressure-boards being longer than the other, or converting human beings into weights (most dangerous substitutes), etc., then the gas on which there is the greatest weight or leverage will be forced over to the other gas receptacle as soon as a free communication is established through the connecting-tubes when the taps are opened, and an explosive mixture will be formed, which most assuredly will ignite, should the weight be removed from the weaker bag or other receptacle while the gases are burning at the nozzle, and an explosion of considerable force will then result. Nearly every accident of the nature here indicated, of which I have been able to trace the history, has resulted from inattention to these simple rules, through weighting the bags with things of indefinite weight—such as a fender on one bag and fire-irons on the other—then trying to correct the defectiveness of the light by pressing the bags with the hands, which has resulted in an explosion as soon as the hands have been removed.

One curious circumstance connected with such explosions is, that I have never heard of their causing *personal* injury; though the pressure-boards have been shattered to splinters, a heavy door taken off its hinges, every pane of glass in the windows of the room blown out, yet, with ten or more people standing round the apparatus, not one has been hurt. I believe that, if a sufficient pressure were kept up on a bladder filled with a mixture of oxygen and hydrogen, the gases might be ignited at the nozzle of the jet without fear of an explosion. The whole secret of safety lies in a nutshell. Keep the oxygen and hydrogen in separate bags; always have sufficient and equal pressure on both bags, and never remove the weights from either bag while the gases are burning. As it is simply impossible to form an explosive mixture with the oxy-calcium arrangement, of course I enforce the above rules in reference to the use of the oxy-hydrogen jet.

MINING AND QUARRYING.—XVI.

BY GEORGE GLADSTONE, F.C.S.

TIN (*continued*).

MINING UNDER THE SEA — DRESSING-FLOORS — STAMPING — WASHING — VANNING — CALCINING — SEPARATION OF WOLFRAM—BLACK TIN—SAMPLING—TICKETING.

Much ingenuity and spirit is exhibited by the miners of Cornwall and Devonshire in the pursuit of the underground riches. In many instances, too, they have shown a remarkable amount of daring, and of perseverance under circumstances of no ordinary difficulty.

The neighbourhood of Penzance was the scene of one of these, where, towards the close of the last century, when the science of engineering was far behind what it is now, a working miner conceived the project of opening a mine on a sand-bank, covered by the tide at high water. A very rich lode of tin was known to pass under the inlet of the sea, because it could be traced in the land on both sides of the bay, and had long been worked as far as it was exposed on the fall of the tide. The spot fixed upon for the workings was about 700 feet distant from the shore; and here the shaft had to be carried upwards till it reached a level above that of the highest spring tides, as well as downwards into the rock: here exposed to the violence of the waves, and to the constant percolation of the water through the woodwork of the shaft, as well as through the fissures of the rock, ore to the value of £70,000 is said to have been raised. An American ship, unfortunately, drove against the works one day in a storm, and this romantically situated mine came to an untimely end.

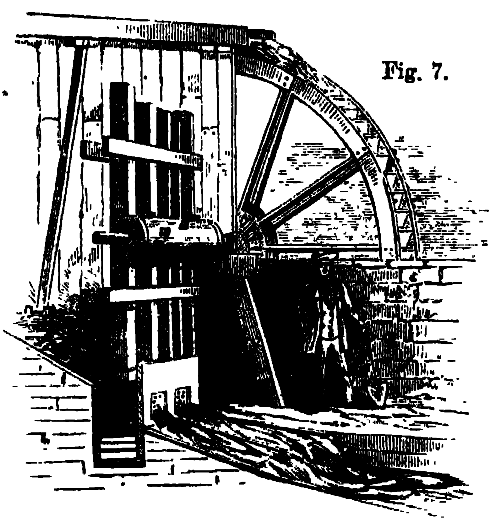


Fig. 7.

Another mine, from which a large quantity of tin as well as copper has been extracted, is situated at the extreme point of land overlooking the Atlantic. The entrance to Botallack mine is about midway between the top of the cliff and the sea; and the underground excavations follow the lodes out seaward to a distance of about 500 feet. Not only do the miners here run the risk of cutting into some fissure which would admit the sea-water at a greater rate than the engines could pump it out, which would lead to the mine being irremediably drowned; but the exposed site of the shaft-heads, with their engines and other works, which are dotted about the face of the cliff, greatly enhances the cost of the works and the labour of the miners.

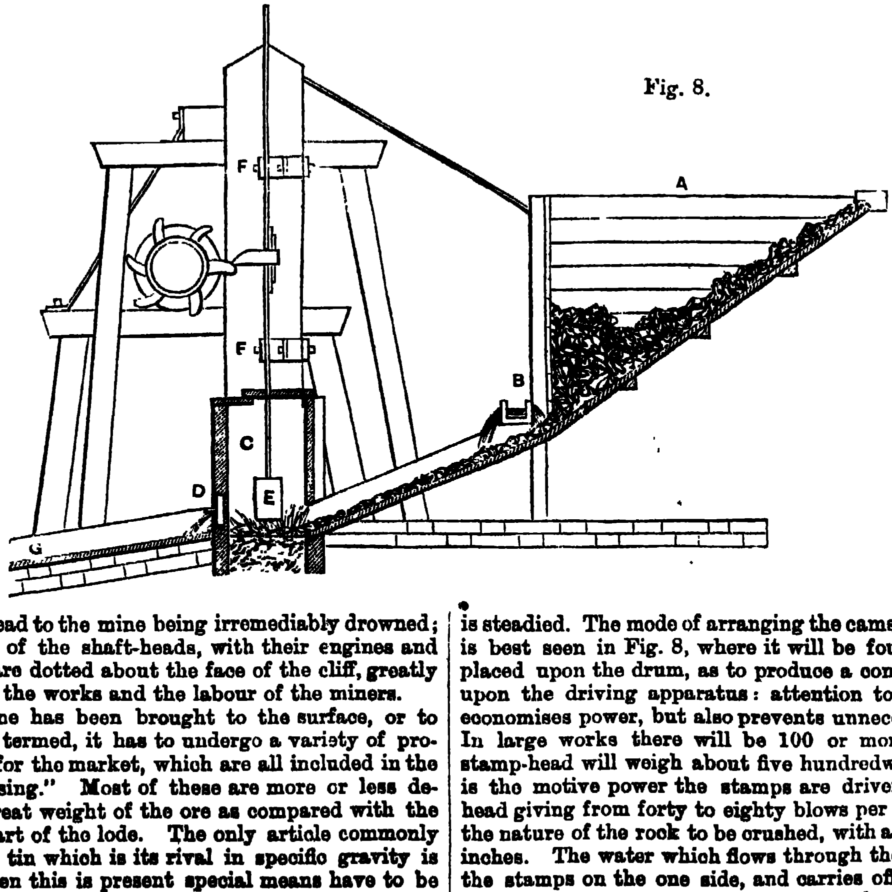


Fig. 8.

When the tin-stone has been brought to the surface, or to *grass* as it is locally termed, it has to undergo a variety of processes to prepare it for the market, which are all included in the general term "dressing." Most of these are more or less dependent upon the great weight of the ore as compared with the gangue, or earthy part of the lode. The only article commonly associated with the tin which is its rival in specific gravity is wolfram, so that when this is present special means have to be adopted for its separation.

Water is the most indispensable article at the dressing-floors, and if a large natural supply is not at hand it must be brought to the spot. The level at which the water is brought in should be considerably above that of the floors, as a good fall is always advantageous.

The ore arrives at the surface in lumps of various sizes, and just in the condition in which it has been shovelled up after a blasting—associated with much dust and dirt. It is therefore customary to wash it first, by passing a stream of water through the heap, which carries away the useless substances. It can then be readily seen what pieces of the stone are valueless, and these are picked out and thrown aside: other lumps may contain a portion of tin-stone associated with a good deal of rubbish, and these are broken with a hammer into smaller pieces, and the useless portions rejected. All the larger lumps of tin-stone are broken up at the same time into pieces of more convenient size, preparatory to their undergoing the next operation.

The ore is so generally disseminated throughout the gangue, and consists of such fine grains, that it cannot be separated by hand; and in order to free it from the earthy substances, the whole of the stone must be finely pulverised. This is ordinarily done by stamping. In former times the stamps were driven by water-power, but now the aid of steam is more commonly accepted, and much larger stamping-mills are now to be seen than when water was the motive power.

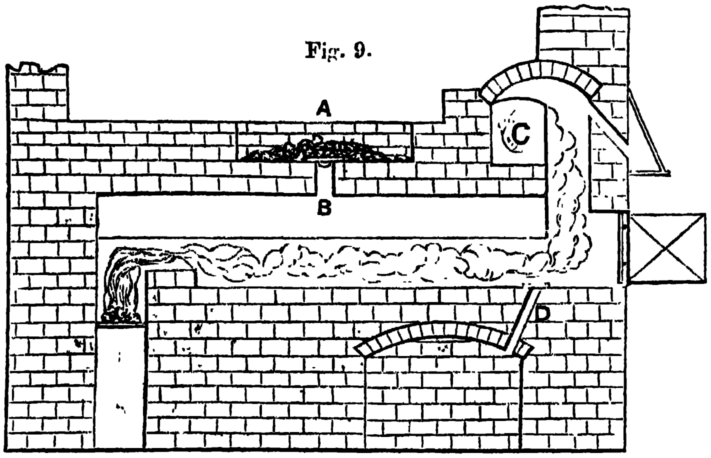
Fig. 7 will serve to illustrate the simplest form, constructed for the most part of wood, and driven by a water-wheel. Fig. 8 is the section of an improved form. The stone to be crushed is supplied gradually from the hopper, A, by the agency of the water which pours from the launder B, carrying the stone with it down the slope into the cofer C, where it comes under the stamps, and is crushed by them until fine enough to pass through the gratings at D. These are usually made so fine as to contain 160 apertures in the square inch. The stamp-head, E, is always made of iron, and in the second diagram it is attached to an iron rod, which works through guides, F F, by which its action is steadied. The mode of arranging the cams for lifting the pestles is best seen in Fig. 8, where it will be found that they are so placed upon the drum, as to produce a constant uniform strain upon the driving apparatus: attention to this point not only economises power, but also prevents unnecessary wear and tear. In large works there will be 100 or more stamps, and each stamp-head will weigh about five hundredweight. When steam is the motive power the stamps are driven very quickly, each head giving from forty to eighty blows per minute, according to the nature of the rock to be crushed, with a fall of seven to eight inches. The water which flows through the cofer not only feeds the stamps on the one side, and carries off the powdered rock through the gratings on the other, but also serves the important purpose of keeping the stamp-heads cool. When the tin-stuff is sufficiently pulverised to pass through the gratings, it is carried by the water down the trough, G, which leads to two basins, one in front of the other. The heavier portion, or "roughs," consisting of little else than oxide of tin, is deposited in the first basin, while the lighter portion, or "slimes," is carried forward to the second. Both deposits are subjected to further washings in order to remove the earthy portions; for which purpose a great variety of different machines have been invented, all, however, based upon the principle of the more rapid subsidence of the metalliferous portion as compared with the rock, when agitated in water.

How certainly it acts may be illustrated by the simple process of vanning, which is frequently adopted when it is necessary to ascertain roughly the character of a pile of stuff from the stamping-mill. A little of the pounded stone is taken up on a shovel that is rather hollow in the middle, and then by causing a little vibratory motion, and dipping it at intervals under the surface of some water, the contents are separated; the tin ore collects on one side of the shovel, the copper ore in the centre, and the waste, which is the lightest, on the opposite side.

The rack or frame is but an adaptation on a large scale of the vanning-shovel. It consists of a long table on a slight incline, down which the slimes are carried by a gentle stream of water, the mixture being continually agitated either by an attendant or by machinery. The purest ore, called "heads," collects at the upper part of the table; a second quality, or middles, lower down; while the tails occupy the extreme end. The middles are usually submitted to the same process a second time, but the heads are sufficiently pure to render this unnecessary.

Any wolfram that may be mixed with the ore will be found in the roughs and heads, being slightly heavier than the oxide of tin itself. Copper and iron pyrites, which are commonly found in all lodes, remain more or less mixed with the tin-stuff, as their specific gravity varies from 4·2 to 5·0; and many of the ores contain arsenical pyrites also, called "tin whits" by the miners. These various substances must be thoroughly separated, and with this object the ore is sent to the calcining furnace. This is made on the reverberatory principle, as the flame from these furnaces is highly oxidising. The ordinary form is shown in Fig. 9.

Fig. 9.



The crushed ore is first put into the drying-bin, A, where it remains till all the moisture is driven off, when it is allowed to fall through the funnel B upon the hearth. The furnace is got up to only a very moderate heat at first, and then gradually increased, care being taken not to exceed a dull red heat, or otherwise the ore would begin to cake together, which would entail both trouble and expense in reducing it again to a powder. The workman rabbles the ore every twenty minutes or so, for the purpose of exposing all parts of it more thoroughly to the action of the flame, and the process is repeated until the white fumes, which have been given off in quantity, cease to appear. These fumes contain much of the sulphur and the arsenic, which have been expelled from the pyrites; and they are carried through a long series of chambers, C, in which the arsenic is deposited on cooling before reaching the chimney. Thus an article of value is obtained, which, if allowed to escape at once into the air, would have a very deleterious effect upon the neighbourhood around. The ore, when sufficiently calcined, is raked through the channel D into the vault below; and is there exposed to the action of the atmosphere for a few days to promote the oxidation of the remaining sulphides into sulphates. The latter, being readily soluble in water, are then removed by washing. The ore is subsequently racked again in the same manner as previously to calcination, and is then fit for the smelter. In some of the large tin mines the calcining furnace is so arranged as to feed itself, and the stirring of the ores is done by machinery, so that it requires no attention beyond that of keeping up a sufficient supply of the tin-stuff in the hopper above.

When wolfram is present in the ore (but it is only in certain mines that such is the case in any quantity), an additional operation is necessary. Wolfram consists chemically of a tungstate of iron and manganese, forming the heavy crystalline insoluble body which has already been mentioned; and it was formerly regarded as so troublesome and deleterious an ingredient, that it used to depress the value of the tin ores of Drake Walls mine (where wolfram is particularly abundant) by 25 per cent. By the adoption of the following simple process the ores from this mine are rendered at least as pure as those of any other in the county; and the tungsten thus separated from the tin becomes a source of income, instead of a loss. The ore having been crushed and dressed as usual, the exact per-centage of wolfram is ascertained by analysis. The ore is then mixed with a sufficient quantity of soda ash, to supply an amount of soda which shall form the chemical equivalent of the tungstic acid in the wolfram. The mixture is then thrown into a reverberatory furnace, and brought up to a dull red heat. This roasting causes the oxidation of the iron and manganese in the wolfram, and at the same time the transfer of the tungstic acid from the former to the alkali, forming a tungstate of soda, which is perfectly soluble in water. After the product of the furnace has cooled down, it is lixiviated in water, by which the soda salt is dissolved out; and the liquor on being evaporated down yields crystals of tungstate of soda. The oxides of iron and manganese, being of much less specific gravity than the tin ore, are removed in the course of the usual rackings subsequent to calcination. The furnace used in this process is of somewhat different construction, the sole being made of iron instead of brick, as the soda ash would attack the silica in the fire-bricks, and carry with it some of the tin also; so that in such case, if fire-bricks were used in the construction of the furnace, there would be some loss of metal, while that which remained would be less valuable, owing to the imperfect removal of the tungstic acid.

The ore, although it has lost its original darkness of colour in the process of calcination, is known in the trade as black tin. Under this name it is sold to the smelters. There are periodic sales at the chief mining centres, prior to which the smelters send their assayers to draw samples of the different parcels. The most exact mode of ascertaining the per-centage and quality of metal in the ore, is to take two ounces of the black tin, and put it in a crucible, with two-thirds of an ounce of culm, and four pennyweights of borax. On subjecting the crucible to a strong heat the metallic tin separates, and the button of metal collects at the bottom of the crucible. This is weighed to find the quantity; and then hammered, its behaviour under the hammer being a sufficient test of its quality.

A more expeditious plan, and one which answers the smelter's purpose equally well, as it returns about a similar proportion of metal to what will be obtained in the regular operations on a large scale, is to mix the sample with about 4 per cent. of pounded coal, put it into an open crucible, and subject it to a high temperature in an air-furnace for a few minutes, when reduction will take place. This plan will return about 5 per cent. less metal than the preceding.

On the day appointed for the sale, the smelters send in their tenders (or "tickets," as they are called in Cornwall), and the highest of these are accepted. Sometimes the black tin is sold by private contract. The produce of most of the streamings, as well as of the small mines which do not raise sufficient ore to make it worth while to erect dressing-floors, is sold in an undressed state by private bargain.

PHOTOGRAPHY—III.

By J. C. Leake.

MANIPULATION OF PLATES FOR TAKING PICTURES.

We may now suppose that the dark room or operating chamber has been duly prepared, as well as the camera, stand, and other apparatus already described; that all the solutions are ready mixed, according to the foregoing instructions; and that the photographer is now ready to commence the taking of pictures. We will therefore proceed to describe the manipulations necessary for the purpose. The first operation will be the cleaning of the glass plate required for the support of the sensitive film of iodide of silver. With respect to the quality of the glass employed, we should advise the use of that known as "patent plate," as, although somewhat expensive at the outset, it will better bear the frequent removal of the film which will be required in case of failure than any of the cheaper varieties. Besides this, a defective glass is a frequent cause of failure, and it is well to reduce the chances of this to the smallest number, in order that they may be more readily traced to their cause, and remedied. Before cleaning the glasses they should be slightly ground on their edges, in order to prevent accidents to the hands when in course of manipulation; this is best effected by rubbing them lightly with a piece of ordinary whetstone, kept damp with water. After this, they should be well washed in abundance of water, and roughly dried with a coarse cloth. A plate may now be fixed in the vice before described, and a few drops of the plate-cleaning solution poured upon it in the centre. This should be applied to all parts of the plate, by means of a tuft of cotton wool; the remaining portion may then be removed by rubbing with a clean soft linen cloth, and the final polish imparted with the prepared soft leather. Both sides of the plate should be thus treated, but that upon which the collodion is to be spread should be tested for cleanliness by breathing upon it. If the breath is condensed in a perfectly smooth and even sheet, without marks and lines, the work of cleaning may be considered as complete and satisfactory, but should any stains or marks appear, the operation of polishing with the leather should be repeated. It frequently happens that beginners clean a plate and rub it until it is dirty. The operation of cleaning is rapidly effected, if proper precautions such as we have stated are taken; and nothing whatever is gained by a long continuance of the process. When the plate is cleaned it should be lightly brushed, to remove any dust which may adhere to its surface, and placed in the grooved box prepared for its reception, taking care to place the best side towards one end which has been marked, so that as each plate is removed the operator may be sure of having that side which is best prepared uppermost. At least six plates should be cleaned before work is commenced, both in order to save time in operating, and to prevent any chance of contaminating the cloths and leathers with the chemicals employed in subsequent parts of the process.

When a sufficient number of the plates have been prepared, enough of the nitrate-of-silver solution should be poured into the bath to rather more than cover the plate, having first rinsed out the vessel with distilled water. The surface of the solution should then be skimmed with a slip of writing-paper, in order to remove any dust or scum which may arise. Into one of the developing-glasses should be poured sufficient of the iron developing solution to cover the plate amply and readily, say two or three fluid ounces; while the second developing-glass should contain about half the quantity of the pyrogallic acid solution, for intensifying. If the water is not laid on into the developing-room, a sufficient supply should be provided in a tub or pail, and a large spouted jug should be placed ready for use. Before proceeding to prepare the sensitive plate, the camera should be arranged in front of the scene to be photographed; and we should advise the tyro to select a tolerably well-lighted view of a building, in partial sunlight, for his first experiment. He should by all means avoid portraiture and difficult subjects, such as foliage or any objects at all likely to move, until such time as he has acquired so perfect a mastery over the instruments used and the chemicals employed as to ensure success as far as these are concerned. The more simple the first experiments are the greater will be the probability of success, and the transition from easy to difficult work will be readily effected as the operator becomes used to his tools. When the camera has been placed in position, and firmly screwed to the stand, the cap of the lens should be removed; and the head of the operator and the ground glass of the camera being enveloped in a dark cloth, in order to exclude the light, it will be observed that upon the ground-glass screen there will be an image more or less distinct of the scene before the camera. This image must be rendered perfectly sharp upon the screen before taking the picture. A rough adjustment may be made by drawing the camera out or closing it, as may be required; but the final one must be made by means of the rack-and-pinion movement of the lens itself. Too much care cannot be taken with this part of the work, as unless the picture be accurately focussed, it will appear blurred and "out of sharp." Of course the camera may be turned to the right or left, so as to include the required view; but any tilting from back to front is not allowable in the ordinary course of work, as this would cause a divergence of the lines in a building, and impart to it an appearance of falling. Of this difficulty and its remedy we shall treat farther on. The camera having been thus arranged, the operator may leave it in position, and proceed to the preparation of the sensitive plate.

The operation of coating a plate with collodion is one which requires some little practice before it can be successfully performed. The two great mistakes which the tyro is likely to make are, first, that of needlessly hurrying the operation; and secondly, that of trying to cover the plate with an insufficient quantity of the fluid. It is true that the coating should be effected quickly, but there is plenty of time to do it steadily, while there is far more danger of spoiling the work by over haste than by a too deliberate method of working. The coating may be performed by daylight, and, consequently, upon entering the operating chamber the yellow screen should be removed from the window before the work is commenced. One of the cleaned plates should be removed from the box by the corners, taking care not to touch the prepared surface with the hand, which would be certain to leave a stain. The operator should stand before the window, and holding the plate with the left hand, and by the lower corner, place it at such an angle with the light as may enable him to see any speck of dust or defect which it may bear upon its surface. The plate should then be lightly brushed, in order to remove any adherent particles of dust on both sides, and of course taking the strictest care with that one which is to receive the coating of collodion. The bottle of iodised collodion should now be taken into the right hand, and the plate being held as nearly level as may be, a good-sized pool of collodion should be poured on to it, nearly in its centre. A gentle inclination should then be made towards the top right-hand corner, so as to cause the fluid to flow in that direction quite up to the edge of the plate. When this is accomplished, incline the plate to the top left-hand corner, and then back, so that the collodion flows back so as nearly but not quite to touch the thumb which holds the plate. Now incline the plate to the right, and holding the collodion bottle under the right-hand bottom corner, allow the excess of fluid to flow back into the bottle; at the same time raise the back edge of the plate, so as to allow the whole of the superfluous collodion to drain off, and impart a gentle rocking motion, in order that all the lines of draining may coalesce and leave a perfectly smooth and even film. It will be of no avail to try to produce a good picture upon a badly-coated plate, as any inequality of thickness will be sure to show in the finished negative. We should therefore advise the operator to make several attempts to perform this operation properly before he proceeds farther in the process, and not to sensitise any plate before he has become well skilled in coating it with collodion, and can effect it with ease and certainty. With a steady hand and practice, the knack of coating a plate will soon be acquired, and this is the first step to really successful work. After an even coating has been obtained, a few seconds should elapse before the plate is immersed in the sensitising bath, the proper time for which may be ascertained by lightly touching the lower corner of the coated surface with the finger. When the film is just set enough to bear a light touch, without receiving any impression of the finger, it will be ready for immersion in the nitrate-of-silver bath. At this stage of the process, a properly prepared plate will appear perfectly transparent, the film of collodion being so thin and even as to be almost invisible. There may be a slight bloom upon the coated side, but it frequently happens that this is so slight as to render it difficult to decide between the plain and covered surfaces.

TECHNICAL DRAWING.—LV.

GOTHIC STONEWORK.

EARLY ENGLISH CAPITALS.

The capitals of this period are usually bell-shaped, and are often, especially in the smaller examples, quite plain, with the exception of a necking and one or two mouldings around the abacus. In such cases they are distinguished from the capitals of later styles, which will be spoken of presently. The bell is generally deeply undercut, which is a strong characteristic of the style. Sometimes the nail-head or dog-tooth ornaments are placed in the hollows between the mouldings. In the larger and richer specimens the bell is covered with foliage, which, springing direct from the necking, is curled over most gracefully beneath the abacus. The foliage, which, from the peculiarity already mentioned, is termed "stiff-leaved," is very bold and striking, and is sometimes so deeply undercut as to be at its upper part entirely detached from the bell. It consists mainly of varieties of the trefoil leaf, thus seeming to show a desire to *aim at* the representation of natural forms, which was so well *accomplished* in the following period, and of which the exaggeration and subsequent *decadence* is seen in the Perpendicular. In clustered piers the capitals follow the form of the pier, as they also adopt the same form in the single shaft, with the exception that multangular shafts have often circular capitals. The base consists of a series of mouldings; frequently of a deep hollow and fillet between two rounds, of which the lower one projects beyond the other. The base most frequently stands upon a double or single plinth, which in the earlier examples is square, having an angle covered with a leaf, which springs from the base and falls over the plinth. In later examples the plinth assumes the form of the base, and is either circular or polygonal. It is sometimes of great height, having a second series of mouldings below the base. The group (Fig. 479) from Stone Church, Kent, is an excellent specimen of Early English capitals, decorated with stiff-leaved foliage and the dog-tooth ornament, which, in this case, is seen between the mouldings of the arch, and is of a perforated character.

Fig. 485.

Fig. 486.

EARLY ENGLISH BUTTRESSES.

The buttresses of this period are for the most part of a simple character, consisting in smaller churches of two or more stages, the lower projecting beyond the other, each set-off being sloped at the top, so as to carry off the rain. Such a simple form of buttress is given in Fig. 480. The buttress finishes at the top, under the parapet or eaves, with a simple slope, similar to that of the other projections.

Fig. 481 illustrates a species of buttress used in larger buildings, which is frequently finished with a triangular head or gable. It is occasionally carried above the parapet, except where stone vaulting is employed, and in such cases it is covered with a pinnacle, which is either plain or ornamented. Sometimes each set-off is finished with a triangular head, and at others the water-table is continued round the three sides of the buttress. The edges of the buttress are often chamfered, as in the example, or the angles ornamented with slender shafts. Occasionally, too, the face of the buttress is sunk into a niche to contain a statue. This, however, is more a characteristic of the Decorated period than of the Early English. As in all the other features of Gothic architecture, the changes from one period to another were so gradual that great difficulty is found in distinguishing between the later portion of the one and the earlier portion of the other. Thus the exact date of a niched buttress would be doubtful were it not for other features connected with it. These will be pointed out in considering the next period. One great distinction must, however, be here noticed, namely, that at the angles of buildings of the Early English style the buttresses are placed at *right angles* to the walls, *as if each wall had been continued beyond the point of junction.* Thus *two* buttresses are required at each angle. In the subsequent periods, however, the buttresses at the angles were placed *diagonally*, and thus only *one* was required at each angle.

Flying buttresses (Fig. 482, from Westminster Abbey), which are arches springing from the wall-buttresses to the clerestory, were first introduced at this period, and are common in all large buildings with vaulted roofs. They are generally of simple design, with a plain capping and archivolt.

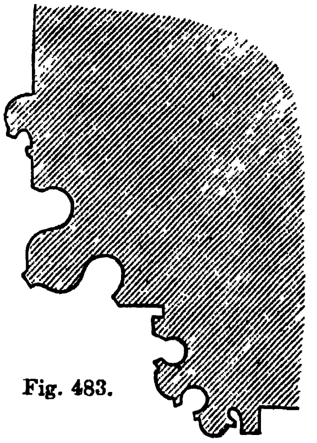


Fig. 483.

EARLY ENGLISH MOULDINGS.

We have seen that the plain square edges of the Norman arches were at first simply rounded off or chamfered. They were then cut into edge-rolls or "bowtells," with side-hollows. The side-hollows were then widened, and the edge-roll set forward on a small neck or shoulder. In the Transition period the bowtell and the roll and fillet were introduced: the mouldings generally became lighter and more numerous; but with the Early English a new principle sprung up in the character of the mouldings. This was the idea of obtaining effective combinations of light and shade by means of *under-cuttings.*

"To such an extravagant extent," said the Rev. T. N. Hutchinson, in his lecture on the subject, "was this carried during the early part of the thirteenth century, that the projecting members of a group of mouldings are often found only united to the arch by a mere neck or thread of stone. Such a combination of projecting rounds and deep hollows would present to the eye the appearance of alternate bands of light and shade, the depth of the hollows causing them to appear absolutely black. This arrangement would be tame and ineffective, were it not for its combination with the rectangular receding faces upon which Early English mouldings were generally cut. By this means a breadth of light and shade was introduced, and the uniformity caused by the alternating bands prevented."

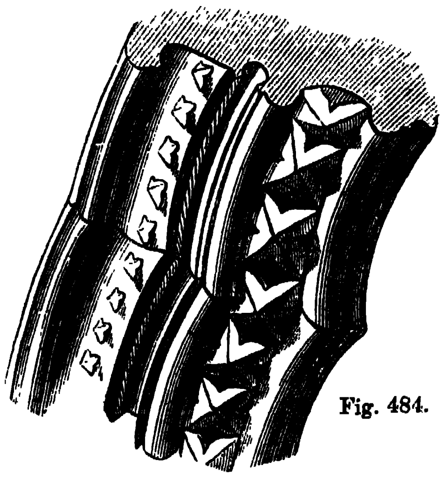


Fig. 484.

The several members of a group of Early English mouldings are generally of nearly equal size. Amongst them the roll and fillet and the pointed bowtell are of constant occurrence, as in Figs. 483 and 484.

About this time a new form of moulding was introduced, which became so generally used in the Decorated period as to form a characteristic feature. This was the "scroll moulding" (Fig. 485). Here again we must refer to the bowtell for its origin; it is, in fact, a bowtell, with one side of the fillet carried round so as to fill up the space between its height and that of the moulding.

The architects of the Decorated period gradually merged the edge of the fillet by a gentle curve into the face of the moulding; and at last it assumed the appearance, so peculiar to the fourteenth century, shown in Fig. 486. It will be seen, on comparing Fig. 485 with Fig. 486, that the angle formed by the edge of the fillet and the moulding below is converted, as it were, into a shallow groove.

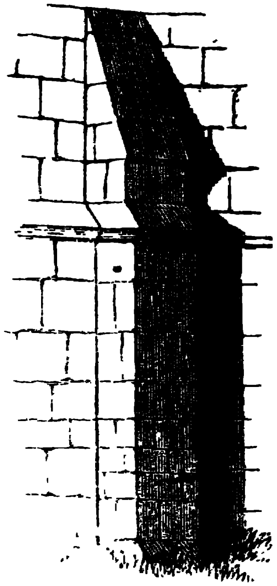


Fig. 480.

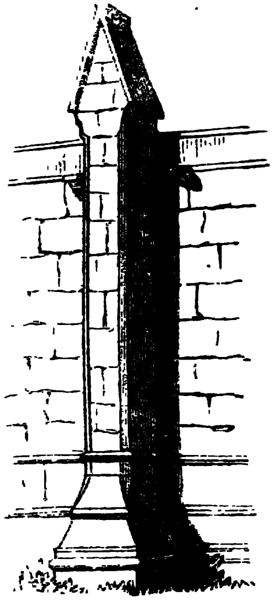


Fig. 481.

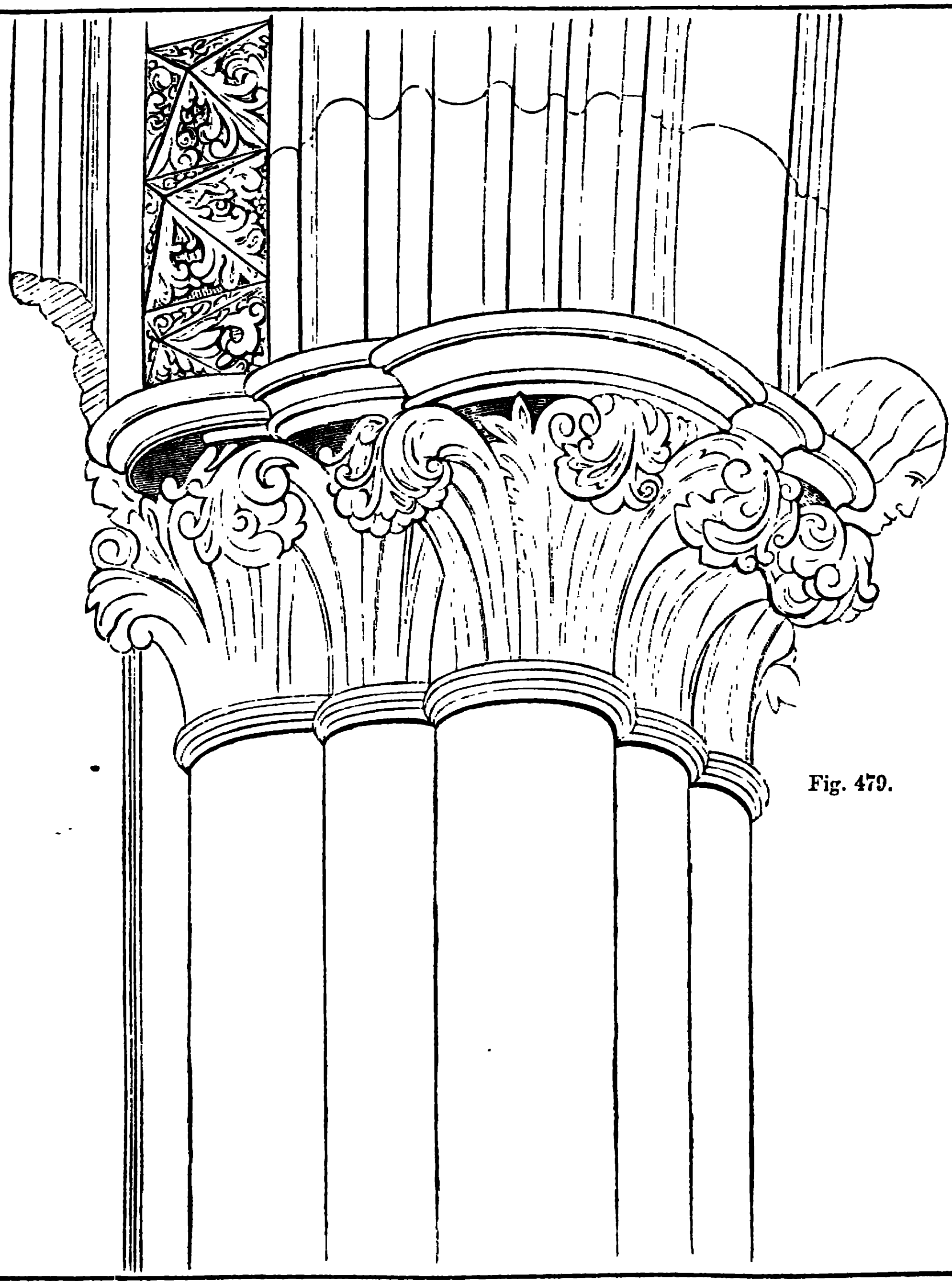


Fig. 479.

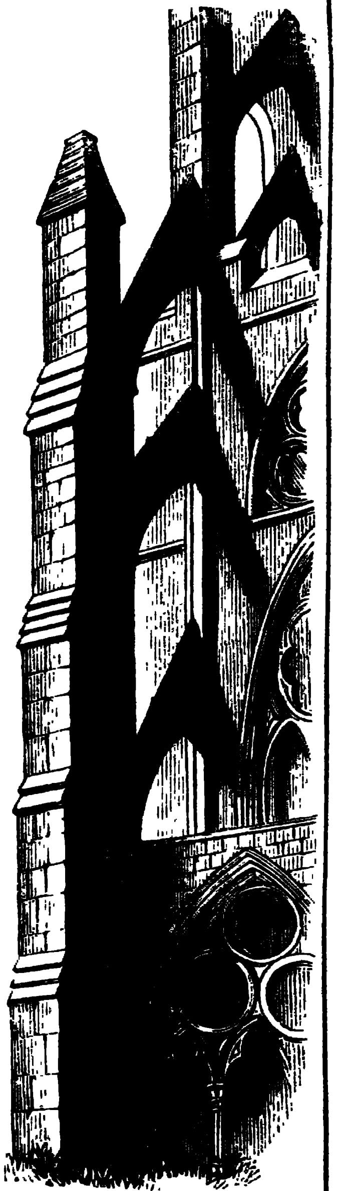


Fig. 482.

FISH CULTURE.—III.

By Greville Fennell.

EXPERIMENTS IN TASMANIA—LOVE OF FISH BY THE FRENCH —BREEDING FISH—METHOD OF EXTRACTING THE EGGS.

Considerable interest is attached to the results of the experiments in Tasmania. The first lot of ova, some 4,000 in number, sent out by Mr. Youll, were hatched in June, 1864, in the river Plenty, a tributary of the Derwent, about seventy miles from the sea; 300 trout (*Salmo trutta*) were hatched at the same time. Several parcels of trout eggs have been sent out since, but those first mentioned were the only ones amongst the number which proved a success, the happy result being attributable to the great care and admirable judgment displayed in their mode of transit by Mr. Youll, and by Messrs. Francis Francis and Frank Buckland in their selection. In June, 1866, from 8,000 to 10,000 salmon ova were hatched out, and about 8.000 salmon trout. Part of the latter, say 1,000, were kept in the breeding ponds on the Plenty to ascertain whether they would breed in fresh waters without going to the ocean. The remainder, with the salmon parr, were in 1868 given their liberty, the ponds being thrown open, and they went to sea.

It appears since that period, that among the supposed salmon trout, some few salmon parr were found to have been left in the ponds; and specimens of this fish, hatched, as we have said, from ova sent out from England, and thus kept in confinement, have been pronounced by Dr. Günther, to whom they were entrusted to be examined, to exhibit characteristics both of the true salmon and the salmon trout. The *produce* of these fish of different kinds bred in the ponds have also been forwarded to Dr. Günther, and have proved to be the true salmon, a fact which has never occurred in the history of pisciculture. These ponds on the river Plenty are admirably constructed; the water is exquisite in its character, gravelly scours or rills are here, there, and everywhere, and a clear sharp stream running continuously over them, and through the ponds; but there is no possibility of salt or even brackish water getting access to them, which renders the above-mentioned facts the more remarkable; indeed the sea, as mentioned, is seventy miles off, and its flow inland up the Derwent comparatively insignificant; the Plenty is, moreover, an affluent of this river far removed by distance and altitude from the influence of the ocean.

No true salmon have, however, yet been caught in the rivers of Tasmania, although at the end of 1870 a net was fixed in the Derwent near the mouth of the Plenty, and several fish weighing from 3 to 4½ lb. and one which weighed 7½ lb. were taken. These fish were at first supposed to be true salmon, but upon a more careful examination they were found to be the salmon trout. The 7½ lb. fish was presented to Governor Ducane, who pronounced it an admirable table fish in every respect. Thus the question forces itself upon us, that as the salmon trout undertook their errand to the sea and faithfully returned to their old quarters, how is it that, with the very same process and under similar conditions, none of the salmon proper have as yet put in an appearance? There are perhaps more than twenty creditable witnesses who were ready to declare, that they could not be mistaken in having seen the salmon swim and leap in the Derwent, and some of these state that they have not only seen them once, but upon several occasions; let us hope they may be right. To prove the presence of fish in the Derwent is not the matter of ease it would be in any of the British streams, or even of those of most parts of the world. In the Derwent it is attended with immense difficulty, which none but those familiar with its waters can imagine. Sunken snags might be removed in time; but the tee-trees which grow upon its banks, send forth their roots under water in every direction to a great length, and present the most formidable obstacle to the working of a net and the safest possible stronghold for the fish. Then the fish are in a primeval state, unaccustomed to the sight of man, or the movement of a boat, and do not partake of that fatal confidence that some kinds of fowls do upon their first introduction to the human form. The fish are off at once, and defy the little art as yet possessed by the inhabitants for their capture.

Mr. Youll deserves every credit for the perseverance and skill he has brought to bear upon the introduction of fish of the *Salmo* tribe into Tasmania, which has been attended with great expense, and many vexatious disappointments. This gentleman's method of packing the ova is ingenious, and, simple as it may read, was the result of many careful experiments. The moss in which the ova are laid is not dead and rootless, but in full vigour of growth, a vitality which the flow from the ice boxes which accompany the eggs perpetuates throughout the whole voyage, and while the temperature is by this means kept down—more particularly in the tropics, where otherwise the eggs would hatch and be destroyed—the ova are preserved as fresh as if they had but just fallen from the parent fish. As, however, some few of the eggs will even in their natural bed become blind and decay, and thus without care prejudicially infect the remaining stock, Mr. Youll underlaid the moss with powdered charcoal, which, acting as a disinfectant, met any threatened difficulty from this cause. No leaden pipes engendering arsenical influences were used on this occasion, and the whole of this vital apparatus was so swung and placed in the space on board the ship devoted to it, as to prevent injurious oscillation and frictional contact. The ova from the fish bred in the Plenty have been safely sent in this manner to Victoria and New Zealand, and in the latter colony they have now many thousands of young trout.

Thus it will be seen that while salmon proper are still a novelty in Tasmania, trout are abundant. Indeed, the success of the trout, both as to their increase and the marvellous rapidity with which they have grown, is most remarkable. There are thousands upon thousands of trout now in the river Plenty and neighbouring waters. During the last spawning season we are assured that "the 'rids,' or nests of the eggs, of this fish extended for several miles, and beautiful fish have been observed engaged in their interesting duties from 3½ up to 12 lb.; and these, we may add with pride and thankfulness, are the fish, the original ova of which was sent to us in benevolent thoughtfulness by Messrs. Francis and Buckland, thus providing the nucleus for an enduring and ever-increasing supply of delicious and nutritious food for all within reach."

To the French people every kind of fish is acceptable as diet, from whatever waters they may be derived. In our own country the salmon and trout grayling are bred artificially as yet, and it is a great question whether the breeding of any other would yield a commercial profit, as fresh-water fish in general with us are much despised, although undeservedly so. We have known perch cost half-a-crown a pound; and there are epicures amongst our aristocracy who make it a practice always to have a pike upon the table. There is, however, no occasion to breed these fish artificially, as they would multiply in sufficient numbers to meet almost any demand, if properly protected. A pike, for instance—according to Mr. Buckland's crucial examination—weighing 32 lb. will produce 595,200 eggs, and a salmon of the same weight will contain about 29,000 eggs, so that it will be evident that a pike produces a much larger proportion of eggs than a salmon.

We might learn a profitable lesson here from the Jews, who are the best patrons of the fresh-water salesman. Barbel, thought by us to contain elements of blood poison, are boiled by the Jews in vinegar and water, and make a most acceptable dish. Dace, which scarcely one English cook out of a hundred can render palatable, a Hebrew *chef* will place upon the table with a *goût*, if not superior, equal to smelts; and roach, and every other fish discarded by us, are made to contribute a welcome and rapid addition to the domestic resources of the poor and wealthy of the thoughtful and industrious children of Israel.

Even the much-abused bream, that of the bronzed or golden kind, are highly esteemed in some parts of England. Indeed, at Gainsborough-on-Trent, there are fishermen who wholly subsist, and make a good living, by angling for this fish during those months in which it is supposed to be in its prime. Chaucer speaks of this bream in terms of eulogy. The belly and fins are the best parts, and are of a rich luscious flavour. Their cost in Gainsborough is about fourpence per pound, and they are much sought after, as, from being caught only by the rod, the supply is uncertain. In France the eel is bred in considerable numbers, and highly prized for the table. In Scotland and some parts of England they are viewed with a perfect loathing; and the keepers—strong and vigorous men—would rather face a wild cat than touch one. Yet so plentiful are eels in some Scotch rivers, that the angler can scarcely get his bait down before it is seized by one; but they are, from their countless numbers, of a very small size, six or eight to the pound being considered large. It has often occurred to us that these eels might be transported to some of our ponds, where, by judicious management and feeding, they could be brought in weight and flavour to great perfection, and yield a handsome profit to the fish-farmer, as the English people in general, being very fond of eels, would be able to consume any quantity that might be offered for sale.

We are, therefore, glad to find that the attention we have called to this subject elsewhere has arrested the notice of Her Majesty's Inspectors of Fisheries in Scotland, Mr. Buckland giving the whole of Appendix No. XX. to its consideration. That gentleman says, "I was much surprised, during my inspection of salmon rivers in Scotland, not to find any apparatus at work for catching eels. I venture, therefore, to state, in my opinion, that the eel fisheries in Scotland should at once be worked. If this were done in a practical manner, I feel confident that a considerable revenue might be derived by individuals from eels, and the public at the same time benefited by an increased supply of good food now quite neglected. It cannot be otherwise, than that thousands of tons of eels *are allowed to escape* down into the sea during the autumn months from the rivers and lakes in Scotland. I have myself on several occasions found young elvers attempting to get over the dam dykes in various parts of Scotland; and a gentleman thoroughly conversant with Scotch fisheries writes me, 'Myriads of elvers ascend the Tay in spring and early summer, and, of course, must descend in autumn and winter, but they are not caught.' What goes on in the Tay doubtless also occurs in most if not all the chief rivers of Scotland. Why should all these tons of eels be lost to the public? I have heard of an eel fishery in Ireland which formerly let for £700 per annum; facilities were given the elvers to get over the dykes, and this fishery now lets for over £2,000 per annum. I am well aware that the Scotch people will not eat eels; they rather look upon them as food with abhorrence; but I imagine the Scotch proprietors of fisheries would not hesitate to sell the produce of their fisheries if they could find a market. The inhabitants of large English towns, such as London, Birmingham, Manchester, Liverpool, Leeds, etc., would have no scruples in taking any quantity of eels; and railway communication is so easy, that eels could be sent to the large English cities from the chief Scotch rivers with the greatest ease." It is to be remarked that the eels are going down when the salmon are coming up. Eel weirs can be set without mischief to the river from June to December; they should be entirely removed from December to June. I sincerely trust the utilisation of the eels in Scotland will not be lost sight of. As for the feasibility of a profit attending a supply, Messrs. Grant and May, the chief dealers in eels in Billingsgate Market, in reply to the question regarding the proposed transport of eels from Scotland to England write, "Eels are caught at some few places in Scotland and sent to market for sale. There is *always* a market here (Billingsgate) for eels."

The destruction of elvers or eel fry in our rivers, when they first appear from the sea admits of little excuse. In the Parret and other rivers which flow into the estuary of the Severn, the eel gala days find a parallel to what used to take place on the Thames' banks. All classes, either personally or by their agents, crowd down to the stream and strain the young fish out literally by thousands; and what for? to make an elver cake, which, for the appetite of a single farmer's boy, would take at least several hundred to satisfy every opening of his unappreciative jaws. Let the Scotch take the above observation to heart, or to the breeches pocket, and keep in view the fact that the owners of the Dutch eel *schugts* have found it worth their while to cross the main and come to Billingsgate from the days of Queen Bess, and have generally amassed considerable wealth by the pursuit of this industry alone. The eel is always in request. It is the food of the poor man when small and of the rich when fat, and of weight; and, as has been said, "a dearth of eels was never known dead or alive if fresh."

The best plan to keep eels in the stews or ponds is to surround the water with that description of wire fencing that curls inwards, which, despite the wonderful acrobatic faculty which they can exercise by the assistance of their prehensile tails, they can not surmount. It may be here remarked that the power in the tail of the eel is something marvellous. By this they can escape out of a deep pail or jar with great facility, presuming that the depth of the utensil is but half an inch shallower than the length of the eel, for that half inch is enough to permit of the eel standing upon its head against the side of its prison, and crooking its tail over the edge like a finger, lifting itself up and out of captivity.

In this country, as we have said, there is little demand for the coarser kinds of fresh-water fish, excepting for the recreation of the rod. On the contrary, in Paris, a visit to the fish markets will shew to what an extent the waters are utilised and the value placed upon all kinds of fish. In France, Germany, and elsewhere abroad, most of the fish for sale are kept alive in large troughs; and a housekeeper would as soon think of putting a fowl down to roast with the feathers on, as purchase a fish she had not seen swimming about and lively at the time she struck the bargain for its possession.

We learn from various authorities the method of extracting the eggs.

M. Gehin says:—"I take a female trout when she is ready to spawn, and—very much importance is, of course, attached to this fact—holding her by the back with my left hand, I prevent her violent efforts by pressing her head and body against it, and with my other hand stroke her belly, till in a few moments she becomes quieted." "All animals," adds an able writer, "are sensible to these caresses, or similar ones made on their backs, and take them willingly; witness the cat and dog, which by purring, whining, rubbing against us, or licking our hands, seek to obtain them." We scarcely subscribe to this, inasmuch as, to render the parallel complete, the cat or dog ought to be put under water, that is, out of their natural element, during this presumedly soothing and mollifying process. The stillness of the fish is more likely to arise from fright, combined with the sensation of smothering which it must necessarily undergo in an element it is not accustomed to. All the caresses bestowed even upon a freshly-caught bird, although in its natural element, do not tend to soothe or allay the rapid beatings of its fearful heart.

When the fish is thus magnetised or "put to sleep," as it has been facetiously termed, it is inclined over a utensil which has been prepared to receive the eggs by putting in it about a quart of water; in order to ensure the fish remaining quiet, another person, if necessary, holds its tail, then M. Gehin, with the thumb and fore-finger of his right hand, presses lightly the belly from top to bottom. This must be carefully and gently done, as one would press from root to extremity a finger cut at the end, to extract the blood and prevent its further flow; or as one would milk a cow, but by no means with so much force as that operation requires, for if the proper time has been chosen, the eggs will be pressed out by a very gentle effort, and if more is required, it will prove that the fish has not gone her full time for spawning, and the eggs thus obtained cannot in that case be fecundated.

Passing the finger and thumb in this manner over the fish's belly, the eggs at each pass will spirt out like the shot out of a shot belt.

When by a number of these passes the eggs are all pressed out, a male fish is taken and operated upon in the same manner; the milt thus expressed from the male, falling into the utensil and upon the eggs, gives the water a white hue. The male fish, like the female, must be subjected to a number of gentle passes to obtain the result. When this is done, the contents of the vase must be stirred about with the hand, or, what is better, with the tail of the male fish still wet with the milt that has run over it (or a feather), an operation resembling that made by the fish in its natural state.

After a very short period the water must be carefully poured off, and a like quantity of fresh water poured on the eggs.

Before the mixture of the milt and the water covering the trout's eggs the eggs are of a pale orange colour, and transparent. After this operation the water must be changed once or twice more.

When the fecundation is complete, some of the eggs will appear white. These are the unfecundated ones, being sterile and dead, and if allowed to remain, will, like all other lifeless things, become putrid, and corrupt the rest; they must, therefore, be carefully removed.

A representation of the method of holding the female trout for the extraction of the eggs has been already given in our first article on this important and interesting subject in page 353 of the second volume of THE TECHNICAL EDUCATOR.

PRINCIPLES OF DESIGN.—XXVI.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

SILVERSMITHS' WORK.

CONTINUING our consideration of hollow vessels, we have now to notice silversmiths' work, and here we may observe that while the material with which we have now to deal differs in character widely from that of which those vessels already considered have been formed, yet that many principles which have been enunciated are equally applicable to the objects now under consideration. Silver objects, like those formed of clay or glass, should perfectly serve the end for which they have been formed; also, the fact that ornament applied to rounded surfaces should be adapted for being viewed in perspective remains as binding on us as before; but herein the works of the silversmith differ from those already considered—they are formed of a material of intrinsic value, which is not the case with articles of earthenware or glass. Silver and gold being materials of considerable worth, it is necessary that the utmost economy be observed in using them, and in order to effect this a special mode of construction must be resorted to. If we propose to ourselves the formation of a sugar-basin of semi-circular shape, of what thickness must the metal be in order that it may not bend when lifted? It is obvious that the vessel must not yield its shape to ordinary pressure, nor be subject to alterations of form when in ordinary use; but if it is to be formed throughout of metal of such thickness as will secure its retaining its shape, it will be costly and heavy, and an amount of metal will be used in its formation sufficient for the manufacture of two or three such articles.

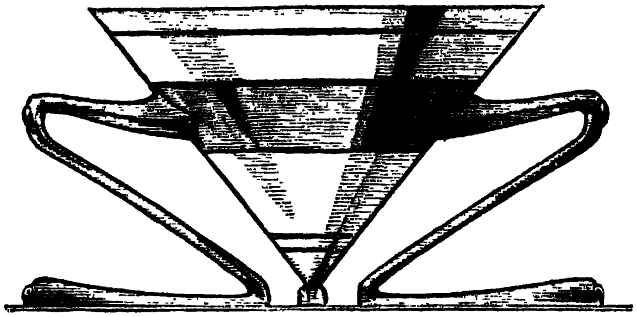


Fig. 122.

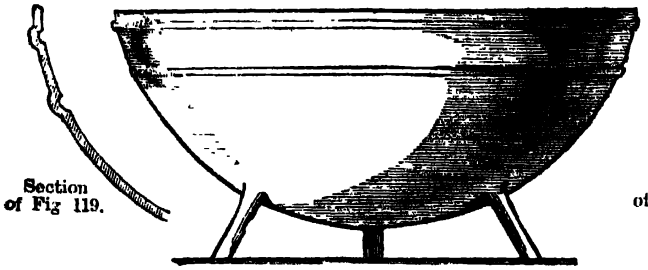


Fig. 119.

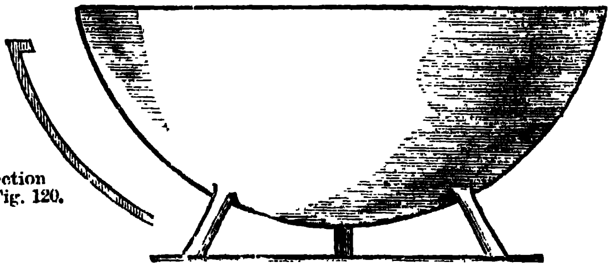


Fig. 120.

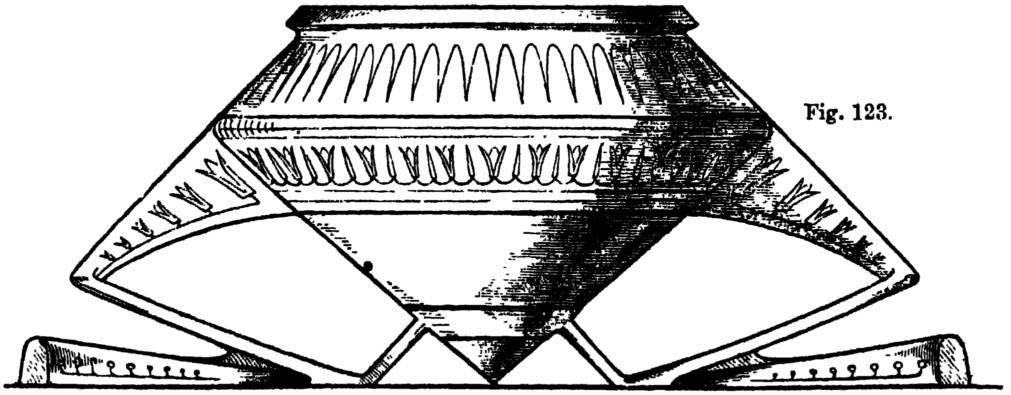


Fig. 123.

Instead of forming the vessel throughout of thick metal, we may construct it from a thin sheet of silver; but in order that it may possess sufficient strength we must indent one or more beads in its side (see Fig. 119); or we can form an angle by having a rim projecting into the basin (Fig. 120), or extending from it, and thus give strength; but the two beads are the more desirable, as the one gives strength at the top and the other at a lower portion of the vessel.

Modes of economising material, when we are forming vessels of costly substances, are of the utmost importance, and should be carefully thought out. If the designer forms works which are expensive, he places them beyond the reach of those who might otherwise enjoy them, and if heavy they appear clumsy in the hands of those accustomed to delicate and beautiful objects.

Besides this, works in silver and in gold are always in danger of being destroyed, owing to the intrinsic value of these metals; and if stolen, the theft is promptly hidden in the melting-pot. Now if we form the vessels of thin metal, we render the money value of the material less, and thus our works are to a smaller degree tempting to the avaricious, and their chance of longevity is greater. The precious metals are at all times perilous materials for the formation of works of art; but while we do use these worthy materials, let us so employ them as to give to our works every possible opportunity for long existence. If a work is to be so formed that it may exist for many years, it becomes of the highest importance that those objects which we create be well considered as to their utility, and at the same time beautiful in form. Long existence is an evil in the case of an ugly object, or an ill-considered vessel; that which is not refining in its influence is better blotted out. Let that man who will not seek to embody beauty in his works make them heavy with metal, so that they may tempt the thief, and thus sooner blot out his works, as they tend only to debase and degrade; but he who loves refinement, and seeks to give chasteness of character to the objects which he creates, may well strive to secure to them length of duration.

There are various modes of working metal. It may be cast, hammered, cut, engraved, and manipulated in various ways.

Little that is satisfactory can result from casting. Casting is a rough means of producing a result, and at best achieves the formation of a mass which may be less troublesome to cut into shape than a more solid piece of metal; but casting without the application of other means of working metal achieves little of an art nature.

Some of the fine iron castings of Berlin are wonderfully good in their way, and are to an extent artistic; and certainly they contrast strangely with the cast handles and knobs which we often see applied to vegetable-dishes, and similar silver objects here in England; yet even these will not compare with works wrought by the hammer and the chisel. Thin metal hammered into form, and touched where necessary with the chisel, the graver, and the chasing-tool, is capable of producing the very finest effects which can be achieved in metal-work. Let the reader consider the beautiful vessels which Arabian metal-work presents us with: these are all formed by the hammer and chisel, with the assistance of the graver and chasing-tool, and how marvellously delicate and beautiful are the results! We have in these vessels beauty and dignity of form, richness of design, great intricacy and delicacy of detail, and altogether a refinement of effect which may long be considered and repeatedly enjoyed (Fig. 121).

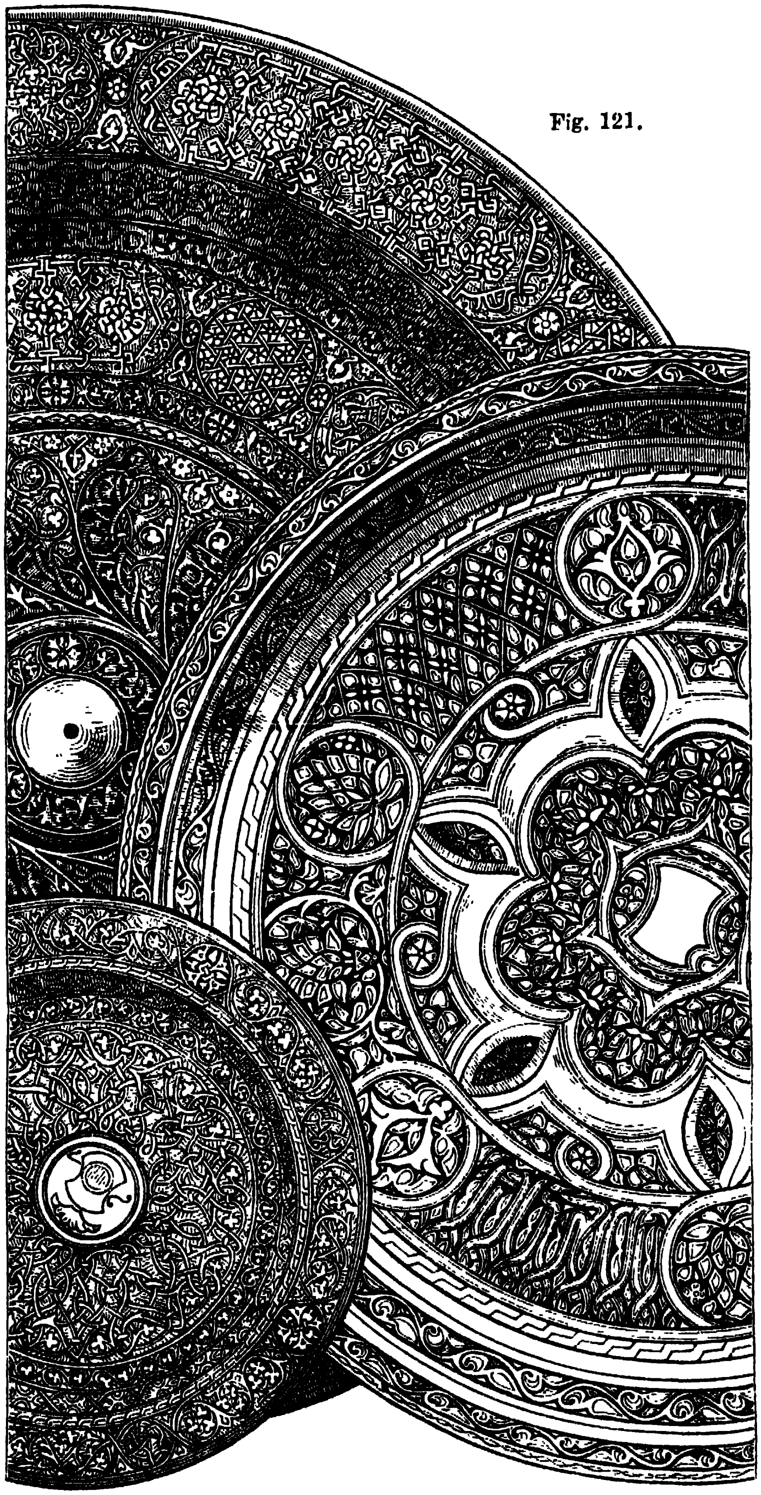


Fig. 121.

Several, I may almost say many, of these beautiful objects are to be found in the South Kensington Museum, and it should be generally known that exact fac-similes of these lovely works, in the form of electrotype copies, have been prepared by Messrs. Elkington and Co., under the sanction of the authorities of the Department of Science and Art, and that these are procurable at small cost. For purposes of study these copies are of almost equal value with the originals, and for the adornment of a sideboard they are hardly inferior. I strongly advise those who can afford to purchase these beautiful copies to garnish their sideboards with plate of this description rather than with the meretricious electro-plate which we often see in our shop-windows.

Having determined on the best mode of working the material, consider carefully the requirements which the work to be produced is intended to meet, and then strive to form the object so that it may perfectly answer the end proposed by its creation.

Let us take a sugar-basin. What form should it have? After much consideration, I have arrived at the conclusion that the two shapes engraved in Figs. 122 and 123 are those which best fulfil the requirements of such a vessel, for in these the sugar is always collected together, and the dust sugar separates itself from the lumps.

The handles of a sugar-basin are often so small as to be partially or wholly useless. It not unfrequently happens that only one or two fingers can rest on the small handle, while the thumb has to be placed within the orifice of the basin when it is desired to move it. This should not be so; if a handle is to exist at all, it should be so formed as to be useful, and afford a means of moving the object with ease and comfort.

To form a handle as a mere ornament is an absurdity, for the handle is part of the vessel structurally, while the ornamentation is an after and separate consideration. In order to its existence a vessel must be constructed, but when formed it need not of necessity be ornamented; ornamentation must ever be regarded as separate from construction.

Such a sugar-basin as I have suggested would not stand without legs: it must therefore have them; but I see no reason why the legs and handles should not be combined; hence I propose three feet so formed as to serve as handles throughout their upper part (Figs. 122, 123), they being convenient to hold.

Modern European silversmiths have fallen into the error (an error now prevailing wherever art can be applied to any object) of making their works of a pictorial, rather than an ornamental character—an error which the Arabians, Indians, and Japanese never perpetrate, while their works in metal are unsurpassed by any others, and equalled by indeed few. It is a mistake to cover an entire vase with figures in high relief; but wherever anything of the kind is attempted, care must be exercised in causing the groups to follow the line of the vase, and not to appear as irregular projections from it. As to the modes of decorating works in silver and in gold, they are many; of ornamentation by *repoussé* work we have already spoken, and of chasing and engraving. But besides these there are other methods, and some of great interest, for there is damascene work, or inlaying, and applying colour, or enamelling, and niello work; jewels may also be added.

Damascene work is of great interest. Metal of one colour is inlaid into metal of another colour. India produces, perhaps, the rarest examples of this kind of work, the Indians being experts at this manufacture; but the Indian work consists chiefly of silver inlaid in iron. This mode of work seems to be capable of producing many beautiful effects, as all who have examined the large inlaid hookahs of India will admit.

CHEMISTRY APPLIED TO THE ARTS.—XV.

BY GEORGE GLADSTONE, F.C.S.

ACETIC ACID.

THIS acid is more familiarly known under the name of vinegar, of which it is the important principle. It is yielded at a certain stage of the fermentation of all sweet vegetable juices; but each of these imparts its own special characteristics, so that the vinegars of commerce are distinguished by the addition of the article from which it is derived, as malt vinegar, wine vinegar, etc. The mode of preparing the qualities in general use will have to be described presently.

The pure acid forms a crystalline solid at any ordinary temperature, having the chemical composition, $C_2H_4O_2$; but it combines with any quantity of water, forming a very pungent, colourless liquid. The absolute acid is usually obtained by distilling the acetates of sodium or potassium with sulphuric acid, stirring a little peroxide of lead into the product, and then re-distilling it. It can also be made by the direct oxidation of alcohol, C_2H_6O, when two atoms of the hydrogen are replaced by one of oxygen. The ordinary processes of the vinegar manufacture will be found to be mere modifications of this latter reaction. The commercial acid is now principally made by the distillation of wood, and hence it is generally known under the name of pyroligneous acid. It is largely used in making the various articles used for manufacturing purposes.

Vinegars seldom contain more than about 5 per cent. of the absolute acid; and their colour and flavour depend materially upon the ingredients from which they are made. In England they are usually made of malt; in France, of grapes; in Germany, of grapes, beetroot, or potatoes.

The ordinary plan is to make a decoction of ground malt in a mash tun, similar to what is used by brewers, 100 gallons of water being used for every six bushels of malt. It is important, in an economical point of view, to extract during the brewing the whole of the saccharine matter contained in the malt; and this is best done, not by putting in all the water at once, but by making two or three separate brews. The first should be heated to about 180° Fahrenheit, the others rather higher, or up to the boiling-point. Of course, the last yield will be much weaker, but they all pass into the same receptacle, and so become mixed together.

The wort thus produced is allowed to settle, and is then drawn off and left to cool; four gallons of yeast are then added, and well stirred in. After remaining about a day and a half, the liquor is transferred to the casks, in which it remains for about three months, by which time it is converted into vinegar. The casks are only partially filled, and have the bung-holes left open and a hole bored in each end near the upper edge, so that there shall be free access of air during the whole time; without this the acetic fermentation will not take place. In summer-time no artificial heat is required for this last operation: the casks are ranged in long tiers in the yard, without any other protection from the weather than a loose cover over the bung-hole during rain. In winter fielding cannot be attempted: the casks are then ranged in apartments which are maintained at a temperature of about 75° Fahrenheit.

The vinegar having thus been made, is drawn off from the casks, and put into the refining vessels to be clarified. These consist of tuns fitted with a double bottom, between which rapes (which are the refuse skins and stalks of grapes from the wine makers) are put, and through which the vinegar has to filter. A tap below the level of the false bottom allows the outflow of the vinegar, after filtration, into a cistern, from which it is pumped up again into the refining vat, to repeat the same operation. This is done several times, until the vinegar becomes quite clear and bright, when it is ready to be put into casks for the market.

There are two practical inconveniences in the process just described—the length of time required, and the large space occupied by the rows of casks. As the action is dependent upon the supply of air to the fermenting wort, it is evident that by increasing the surface of the liquor which is exposed to this oxidising influence, a larger quantity will become acetified in the same space of time. Various plans have therefore been suggested for the more rapid production of vinegar, all dependent upon this one idea. In one of these the liquor is made to pass through a large tun filled with beech-wood shavings, near the bottom of which holes are bored to admit the air, while in the lid are little pipes or chimneys for carrying off the waste gases. By this arrangement the liquid gradually trickles down, exposing an immense surface to the air, which at the same time is passing upwards through the vat, and the final result is accelerated in proportion. When a vat is fresh started, some hot, strong vinegar is passed through it for a day or two, in order to saturate the shavings and give them the character of mother liquor, which expedites the conversion of the rest. While the acetification is going on in the vat the temperature must be carefully watched with a thermometer, as the tendency of the operation is to generate heat, and if this proceeds too far, the spirit is driven off in the shape of aldehyde (C_2H_4O), which is a highly volatile substance, and a proportionate quantity of vinegar is lost.

Another adaptation of the same principle is to introduce the wort through a pipe which runs perpendicularly through the centre of the vat, the pipe being pierced with holes and made to revolve. The liquid is thus thrown in the form of a shower upon the shavings, and so presents a great extent of surface to the action of the air.

Vinegars are known in the trade by the numbers 18, 20, 22, 24, which represent respectively the number of grains of carbonate of sodium which will neutralise an ounce by measure of the liquid, and hence indicate the proportion of acid contained in the vinegar, No. 24 being equal to about 5 per cent. For domestic purposes No. 22 is preferable, as being sufficiently strong. It is highly valuable as a preservative from decomposition, on account of its coagulating the albuminous portions of animal matter, and more particularly of fish. It exercises the same function with respect to vegetable substances in converting them into pickles; and its liberal use is particularly to be desired on shipboard, and under any other circumstances where fresh meat and vegetables cannot be procured in sufficient quantity. Vinegar, however, being a product of fermentation, is itself, nevertheless, liable to putrefaction, the mothers consisting of an accumulation of a fungoid plant called *mycoderma vini*. The propagation of this plant, or of worms, in the vinegar, is often stopped by the addition of not exceeding 1 per cent. of sulphuric acid.

For manufacturing purposes the acetic acid made by the destructive distillation of wood is principally employed. On account of its origin, it is very commonly called "wood spirit." The plan adopted in its manufacture is a comparatively simple one. An iron cylinder or box forms the receptacle for the wood to be distilled, immediately underneath which is the furnace. From the upper part of the retort a pipe passes into the condensing chamber, where it is cooled by a stream of fresh water playing upon its outer surface, the condensed vapour pouring out into the receiver at the further end. The distillate, as it first comes over, consists of a mixture of water, acetic acid, naphtha, and tar, which are separated by re-distillation, the naphtha coming off at a lower temperature than the other ingredients, and the tar being the last to remain in the retort.

The quantity of acid produced varies according to the kind of timber used, within the limits of 6½ to 7½ ounces per pound of wood; but, when the distillation is over, there remains behind from 3⅓ to 4⅓ ounces of charcoal, which, in this country especially, where wood is dear, is an article of considerable value. In order to economise waste products, some manufacturers convert sawdust, spent tan and dyewoods, into pyroligneous acid, after they have fulfilled their more special uses.

In some works the acid vapour, as it passes from the carbonising cylinder, is brought at once into contact with one or other of the bases with which it has a strong affinity, so that it at once enters into combination and forms an acetate, which can either be used as such, or from which a very pure acid can easily be prepared.

When the acid has been made by the first-named process, it has to be still further freed from the oily and tarry matters which may yet remain more or less mixed with it. This is usually done by converting it into the acetate of calcium, by boiling it up with an excess of lime and water, so as to ensure the whole of the acid being taken up. The excess of lime is then allowed to settle, the solution is drawn off, and then evaporated down until the whole of the acetate of calcium crystallises out, which is then distilled with sulphuric acid.

Some of the preparations made from this acid, such as acetic ether and aromatic vinegar, are used in pharmacy. The former is made by distilling the anhydrous acetate of sodium with a mixture of sulphuric acid and absolute alcohol, in the proportions of 28 per cent. of the former and 32 per cent. of the latter to 40 per cent. of the salt. The product is neutralised with bicarbonate of soda, then agitated with chloride of calcium until all the water mixed with it has been absorbed, and finally re-distilled.

But the most useful compounds are the acetates, which are largely employed in the arts. They have been already referred to in the former articles of this series, which treat of bleaching and calico printing, but their preparation and use deserve to be more fully considered.

Acetic acid combines with iron in two different proportions. The ferrous acetate, $FeC_2H_3O_2$, is commonly made by digesting scrap iron with the crude wood spirit at a temperature of 150° Fahrenheit, or by decomposing a solution of copperas (sulphate of iron) with acetate of calcium. This salt produces with madder a deep black dye. The ferric acetate, $Fe_2 3(C_2H_3O_2)$, formed by dissolving the sesquioxide in acetic acid, or by mixing solutions of the ferric sulphate and acetate of barium or lead, is also much used by dyers. With ferrocyanide of potassium the former of these salts produces a blue colour, and the latter a brown.

Acetate of lead is also employed by dyers and calico printers. It may be prepared in several ways. One plan is to expose sheet lead in a close chamber to the fumes of acetic acid, which causes the metal to corrode and be covered with a mixture of carbonate and acetate, which is then scraped off and dissolved in a slight excess of acetic acid. On evaporating down the solution the acetate of lead will crystallise out. Another plan is to dissolve litharge in acetic acid, and crystallise out the resulting salt.

The acetate of manganese is made by decomposing the sulphate of manganese with acetate of calcium or lead. It is also used in dyeing and calico printing for producing a brown colour by the action of chloride of calcium.

The tin salt is used in producing spirit colours. In preparing this, the protochloride of tin dissolved in water is mixed with acetate of lead.

Acetate of copper, more commonly known as verdigris, is a very useful preparation, not only to the calico printer, but also to the maker of painters' colours. A process of manufacture very largely adopted is similar to that above described for making the lead salt. Thin sheets of copper are submitted in a close chamber to the action of the acid, and from time to time the verdigris which has accumulated on their surface is scraped off. Another plan, more commonly adopted in France, is to substitute the skins and other refuse of the grapes from which the juice has been expressed for wine, instead of the acid itself. The sheets of copper, first dipped in a solution of verdigris, and the grape skins, are placed in casks in alternate layers, and are thus left to ferment for twelve to twenty days, by which time a thick coating of green crystals will appear over the surface of the metal. The acetate is then scraped off, and the plates are ready for a second operation. In addition to being used for the purpose of producing colour, it is employed as a resist paste in calico printing, when a white pattern is required upon a cloth which has to be dyed with indigo.

There is still another very important compound to be touched upon. The use of alum as a mordant has been spoken of under that head in Article X., and one of the most convenient modes of using it is in the condition of a sesquiacetate of alumina. It is made by dissolving alum in a solution of acetate of calcium, a sufficient quantity of the former being supplied to decompose thoroughly the lime salt.

CIVIL ENGINEERING.—XIII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BREAKWATERS.

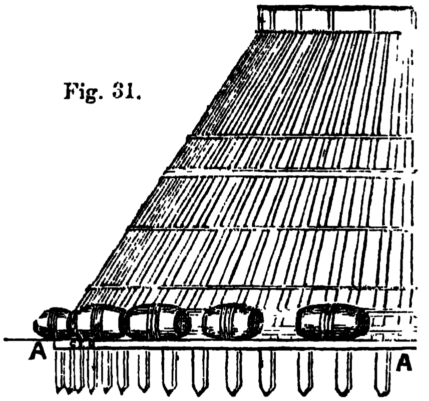
THESE most useful, and, indeed, indispensable adjuncts to harbours having a certain aspect and formation, are of two kinds—fixed and floating. Any work, whether natural or artificial, which serves to break the violence of the waves, or the set of a current, may be denominated a "breakwater." From the exposed positions they of necessity occupy, the greatest care must be exercised in their construction.

Breakwaters date from a very early period. Their importance for the protection of shipping was appreciated by the earliest settlers upon the coasts of the Mediterranean, who frequently fixed the site of their coast towns in localities sheltered from the prevailing winds by some natural island or rock, and in some cases producing an excellent and well-sheltered harbour by the construction of a mole resting upon some natural formation. This plan was adopted by Dinocrates, the engineer employed by Alexander the Great in the construction of the harbour of Alexandria. Taking advantage of the island of Pharos, which lay at some distance from the mainland, and opposite the site marked out for the city, Dinocrates united it with the mainland by an extensive causeway, or earthen wall. This grand terrace divided the bay into two harbours, which communicated with each other by means of two openings left for the passage of ships. To render the harbour approachable at all times, a lighthouse was built on a rock some distance from the eastern extremity of the island.

The method adopted by the Romans in the construction of some of their breakwaters was as follows:—In situations which the depth or calmness of the sea would admit of, two ranges of piles, secured firmly together with chains, were driven in the line of the proposed breakwater. The earth was then taken out from between the two ranges, and the bed levelled. Mortar, consisting of two parts of a peculiar earth, found near Cumæ, and one of lime—a compound which possesses the property of hardening under water—was then thrown into the space between the piles, together with a proportional quantity of stones, until it was entirely filled. This course was not, however, always practicable, because if the sea were violent the mortar ran the risk of being washed away before it became hardened. In this case they adopted a most ingenious contrivance for building blocks of concrete close to the position they would occupy when submerged, and allowing the action of the water to carry them, when hardened, into the position intended. The method adopted was to build a strong platform of hewn stone blocks immediately adjoining the sea. A portion of this platform was horizontal, whilst that part facing the sea inclined towards it. On the flanks of the inclined plane walls were built projecting 18 inches above its face, and upon this enclosed space sand was laid. On this sand they commenced building a concrete block, and as soon as it was hardened by exposure to the air, the enclosing walls were removed, when, the sea gaining access to the sand, washed it away, and, leaving the block unsupported on a horizontal plane, it slid down the slope into the water. This process—slow, though sure—was repeated until the work was advanced as far as desired.

The value in marine engineering of *hydraulic* mortar, as it is termed, by which is implied mortar which will harden under water, is exceedingly great. As we shall have frequent occasion to allude to its employment, it will be as well in this place to describe its composition and character. Hydraulic mortars are usually composed of silica and caustic lime, and their peculiar property of becoming hard under water may be attributed to their forming a hydrated silicate of lime. When clay and magnesia are added, silicates of greater consistency and strength are produced.* The silica should be prepared by calcining it with an alkaline earth at a bright red heat, after which it will dissolve in acids, and form a gelatinous paste. If quartzose sand is mixed with lime in the ordinary way, it will *not* form hydraulic mortar; but if it be burnt with lime after being reduced to fine grains, it will form a suitable ingredient for the purpose. Limestone containing 10 per cent. of clay, when strongly burnt, forms good hydraulic mortar, but if it contain a higher proportion of clay it will not set unless it is well ground. The Romans made use of pozzuolana very largely in forming their hydraulic mortars. This substance is a species of sand found abundantly in the neighbourhood of Rome. The catacombs were probably formed by the extraction of this material. That found near Baiæ, when mixed with lime and rubble, will harden under water as well, if not better, than when exposed to the air. Indeed, it appears that mortar so constituted becomes light and dry when exposed to a dry heat; but, when moisture supervenes, the particles cohere in such a manner that no action of water can disunite them. Limes, when mixed with sand or grains of silex to form ordinary mortar, being very soluble in water, remain in a soft state when excluded from the air for a length of time; but when a small portion of pozzuolana is added in a finely-divided state, the lime loses its solubility, and in a short time hardens under water. This is most probably caused by a chemical combination taking place between the lime and the pozzuolana. The Romans formed hydraulic mortar also by combining pure lime with large proportions of pounded brick. They employed mortar of this description to line their reservoirs, and such mortars often exhibit a coating of carbonate of lime on their surface, but the mortar itself is extremely hard. Smeaton employed, in the erection of the Eddystone lighthouse, a mortar consisting of equal measures of Aberthaw lime, in the state of hydrate, and of finely-powdered pozzuolana. The quality of the limestone employed in the formation of hydraulic lime is of the utmost importance; that which contains clay, magnesia, iron, or manganese, in the proportion of not more than from 15 to 18 parts in 100 of the whole, is suitable. Mortar formed from such lime will set after six or seven days' immersion, and will continue to acquire hardness. Mortar formed with lime obtained from limestone which has, in addition, a greater amount of silica, will set on the second or third day after immersion, and in a month will become hard and perfectly insoluble. Lime is said to "set" when it will bear, without depression, a rod one-twentieth of an inch in diameter, loaded with a weight of 10 ounces avoirdupois. From the foregoing, it may be stated as a well-ascertained fact that no good hydraulic mortar can be made without silica. The action of heat upon limestone is to drive off the carbonic acid and water. If limestone is pure it will bear a white heat; but if it contains the properties necessary to render it a good hydraulic lime, it easily fuses; its calcination, therefore, requires more care. The heat should never exceed redness, and the burning should not proceed too rapidly. If exposed to too great a heat it becomes vitrified on the surface, and the carbonic acid is not driven off; consequently it will not slack. Hydraulic lime is now artificially prepared by mixing a certain proportion of alumina or clay with a "rich" lime, and then calcining it. By a *rich* lime is implied a lime that doubles its volume in slaking, and retains its consistency after being immersed for a length of time, and which will *entirely* dissolve in pure water. Such a lime will absorb nearly three times its weight of water in slaking. A *poor* lime, on the contrary, does not much augment its volume, and will only partially dissolve, absorbing not more than about 200 per cent. of water. With hydraulic lime artificially prepared, as above stated, a mass composed of hydraulic lime and rubble is made, called *béton*, the lime being slaked previous to its mixture. This *béton* sets well under water, and is very generally employed in France, where the piers of bridges and other submarine works are founded upon it, the *béton* being composed of sand, flint, and artificial hydraulic lime. The proportion of lime and clay for the manufacture of hydraulic lime must vary according to their quality; as a rule, 20 parts of dry clay added to 80 parts of rich unslaked lime, or to 140 parts of carbonate of lime, is found to be a good proportion; the finest and softest clays are always preferred. Hydraulic cement can be made containing 34 parts of clay, and 62 of carbonate of lime; and a lime obtained at Harwich, which sets very quickly, has 47 parts of clay, and 49 of carbonate of lime. Parker's cement, patented in 1796, is formed from a limestone found in beds of clay. It exists as nodules, which are called *septaria*, and contains 55 parts of lime, 38 of alumina, and 7 of oxide of iron. Smeaton considered *minion*, or siftings of the ironstone after calcination at the iron furnaces and ground in a mill, equivalent to as much pozzuolana, and he employed this minion in making hydraulic mortar.

Fig. 31.



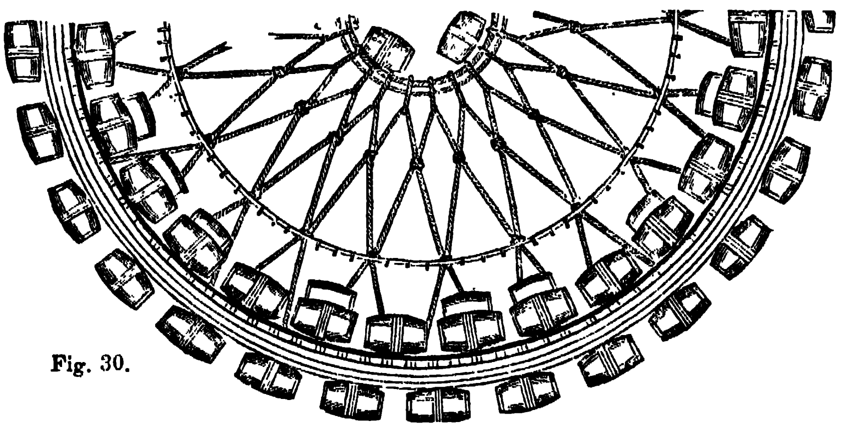


Fig. 30.

The pozzuolana we have alluded to is composed of silica and alumina, varying in their proportions according to the locality it is taken from. That obtained near Naples is of volcanic origin, and when carefully analysed has been found to contain:

Silica	44·5	Oxide of iron	12·0
Alumina	15·0	Soda	4·0
Lime	8·8	Potash	1·4
Magnesia	4·7	Water	9·2

We have dwelt somewhat lengthily upon the character and qualifications of hydraulic mortar, because it occupies so highly an important position in all matters connected with submarine engineering, and because too much care cannot be bestowed upon its formation. We now return to our more immediate subject.

An *open* mole, or breakwater, was occasionally adopted by the Romans, and it undoubtedly has its advantages in some situations. It consists of a line of very strongly-constructed arches, and the remains, which still exist, of some of these open moles at Pozzuoli and Misenum show that the span of the arches was made equal to their depth, whilst the piers were half as wide again as the apertures. From the great depth of water in which some of the piers stand, there can be no doubt but that coffer-dams were employed in their construction. These coffer-dams might have consisted of a large galley having its sides considerably raised, and sunk to the bottom by weighty ballast, when, by heaping clay around the sunken craft, the bottom might be removed, and the foundations of the pier laid. These open breakwaters had considerable advantages in breaking the force of the waves, without hindering the flow of the water, so that no risk was run of the enclosed harbour becoming silted up. The mole at Misenum consists of a *double* open mole, the two lines of arches being so arranged as that the piers of one row stand immediately facing the openings of the other; thus a still greater barrier existed to break the force of the waves, and no risk of silting up existed.

We shall now have to direct attention to the celebrated breakwater opposite the port of Cherbourg, commenced in 1783 by Louis Alexander de Cessart. It was necessary, owing to the depth and violence of the sea at the locality fixed upon for this structure, that some portions of it should be carried up to the height of 80 feet. To obviate the difficulty of building a solid mole, Cessart suggested the use of large truncated wooden cones, loaded with stone, and placed in a line at a distance of 1½ miles from the shore. These cones were prepared on land, and floated to their destined position. All above the level of low water, after they were sunk, was to be filled up with masonry, faced with granite, and laid in pozzuolana.

The method of constructing the cones was as follows:—A circle of 150 feet diameter was traced out upon a platform previously laid down on the shore. Around this were set up 90 timbers, at a distance of about 5 feet 3 inches from centre to centre, and so inclined towards the centre that at the top they were gathered into a circle of about 64 feet diameter; the perpendicular height of the cone was nearly 70 feet. Each of the inclined timbers consisted alternately of five and six pieces.

The scantling of the timbers at bottom was about 13 inches square, and gradually diminished to 8 inches square at the top. The respective pieces were joined by a dovetailed scarf, 18 inches in length, the two ends of the scarf being secured by iron bolts and nuts. The inclined timbers were bound together by parallel horizontal rows or rings of timber, six rows on the outside, and twenty-four in the inside. These timbers consisted of oak and beech, and had a scantling of 13 inches square.

In order to float these immense timber structures, Cessart had recourse to casks, which he preferred to vessels, as being more under the control of the engineer, and more easily detached. The casks employed were 12 feet long, and 7 feet in diameter, and had each a power of flotation equal to about 28,000 lb. The entire cone, when completed, was calculated to weigh two millions of pounds, and, to ensure buoyancy, 35 casks were attached to the inside of the base of the cone, and 49 to the outside, whilst 31 smaller casks were placed inside. These casks were fastened by ropes to the structure, at regular intervals, all round, and in order to secure simultaneous action in the removal of the casks when the structure was floated over its proper position, loaded knives, similar to the guillotine, were suspended over each rope which held a cask; these being suspended from the upper part of the cone by ropes, could at any moment be let fall, when the released cask would come away.

Cessart arranged that certain casks at diametrically opposite points of the cone should be released at the same moment, and, upon a given signal, the cone being floated over its proper position, twenty-two of the casks were released, when immediately the cone sank 18 feet. Thus, by degrees, was each cone settled down upon its bed. The number of cones sunk was eighteen, and these were placed at irregular intervals, the extreme length occupied by their line being 12,470 feet, measured from the centre of the two extremes. After the cones were placed they were loaded with stone, and a great quantity was thrown in around their bases, and between their several intervals, for the purpose of breaking the force of the sea, the amount of stone deposited exceeding in the total 100 millions of cubic feet. This breakwater cost altogether upwards of £900,000. The timber of the cones soon went to decay from neglect, and the stones they contained fell into a natural slope with those around them. We subjoin two illustrations of this truly bold and original undertaking. Fig. 30 shows a portion of plan of the cone, with the casks attached around the base, and the interwoven ropes tending to the centre of the cone, in order to prevent the structure from spreading out. Fig. 31 represents an elevation of the cone, the sloping timbers resting at their foot upon a circular framing at A, and leaning towards a centre at the top. Vertical pieces sharpened as piles were fixed at the base, in order to take hold of the ground when sunk.

A breakwater of an important character, owing to its great usefulness, was erected at the mouth of the harbour at Aberdeen by Telford. This work was commenced in 1808. So far back as 1769 it was contemplated to improve the harbour. The north-easterly winds, which frequently blow with great violence on this coast, were found to drive large deposits of sand, gravel, and shingle, which accumulated outside the mouth of the Dee, into the main channel, and choked it up. Smeaton was the first engineer whose assistance was sought for to remedy the evil. The position of the harbour's mouth is peculiar. The river Dee finds its way into the German Ocean immediately to the north of a projecting head of land, stretching for nearly a mile due east. This head receives the full force of a north and north-east wind, there being no counter-projection for many miles to the north. The result is that the set of the tide carries with it the sand, which forms the chief characteristic of this coast, and deposits it at the mouth of the river, which, except when there is an abundance of land-water, cannot force its way through the accumulation at ebb-tide. Smeaton, guided by his observations of this circumstance, recommended the erection of the north pier to serve the double purpose of a breakwater, and also to confine the land freshets till they arrived at the deep water, and to prevent the sand and gravel from being driven in.

He designed this pier in three sections. The first, resting upon the land, and not subject to the effects of the sea, was 400 feet long, 20 feet broad at the base, 12 feet at the top, and 12 feet high. The second section was also 400 feet long, but the base was extended to 28 feet, the top to 14·5 feet, and the height 20 feet. The third section extended 546 feet further, and had a mean breadth of 36 feet at the base, and 24 feet at the top. The mean thickness of the sides was 4·5 feet, and the space between was filled in with rough stones. The parapet was 4·5 feet thick at the base, and 3 feet at the top, and was 4 feet high. The cost of this pier was £10,000. It was completed in 1778. The effect of the pier was what had been anticipated, so far as freeing the passage was concerned, but it also had the effect of permitting the full force of the unbroken waves to enter the harbour and to expend themselves upon anything therein.

This was too serious an evil to remain. Smeaton therefore suggested that from the south side of the mouth formed by the north pier, a catch-pier or breakwater should be formed by the deposit of rough granite stones, projecting towards the middle of the open space, and inclining within the harbour. This, he thought, would catch the swell of the waves, and throw them away from the harbour upon the headland already alluded to; leaving at the same time a clear passage of 300 feet for vessels entering the harbour.

This catch-pier was formed of blocks of split granite, this work being done at the quarries. They were cut into wedge-shaped pieces, and made of parallel faces, each alternate stone composing the circular end of the pier being a header, the others tending towards the centre. The header stones were firmly secured by their small and inside ends to a cross stone by means of an iron cramp; these being secured, the reversed stones could not, of course, move. The iron cramps which secured the header-stones were an inch square, turned down at their ends, and fitted into holes "jumped" in the stone, not leaded, but retained by wooden wedges, as the weight of the courses above was sufficient to keep them in their places.

GREAT MANUFACTURES OF LITTLE THINGS.—IV.

PINS.

BY CHARLES HIBBS.

The visitor to a modern pin factory, who sees before him a row of very noisy and excited little machines, each taking in wire at one extremity, and delivering perfect pins at the other, in a continual stream, without more attention than is involved in presenting a new coil of wire to be swallowed when the former one is run out, will be struck by the contrast between the pin manufacture of to-day, and that described by Adam Smith, a century ago. That great economist, it is familiarly known, chose the making of a pin as the aptest illustration of the advantages of division of labour. "One man draws out the wire; another straights it; a third cuts it; a fourth points it; a fifth grinds it at the top for receiving the head; to make the head, requires two or three distinct operations; to put it on is a peculiar business; to whiten the pins is another; it is even a trade by itself to put them in the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them." In this way, argued the author of the "Wealth of Nations," a man was enabled to produce some thousands of pins in a day, whereas, without division of labour, he could scarce, perhaps, make one, and certainly not twenty. Each of the machines now in use will turn out 300 perfect pins in a minute, and one man, with the assistance of one or two boys, can attend to ten or twelve machines. The statistics of this industry contradict the usual economic theory, that the introduction of machinery benefits the labourer by increasing the demand for his services. As the result of a somewhat painstaking inquiry, the following may be taken as an approximate estimate of the numbers employed in the best days of the old system of hand manufacture:—Skilled handicraftsmen, stamp-setters, pointers, drawers, head-cutters, whiteners, etc., 320; women and children, employed in heading and sticking, 3,900; in all, 4,220. In addition to these, pin-heading found an occupation for a large number of youthful criminals and paupers in our gaols and workhouses. At the present time the total numbers employed would certainly not reach 1,000, although the production of pins has, perhaps, multiplied sevenfold. The earnings of the men are also much smaller than in the old times. A pin-pointer of ordinary skill could earn on an average £3 per week; a drawer or head-cutter could make nearly as much; while a stamp-setter, who was, properly speaking, a sort of sub-contractor, employing women and children, and making a profit out of their labour, could realise from £5 to £10 per week. Few men now earn more than from 30s. to 40s. at any branch of the trade. The women employed in the modern manufacture certainly earn more than double the wages formerly paid, but then their numbers are but as 1 to 40. Neither does it appear that the manufacturer has been much of a gainer, the profits on the business, consequent on the introduction of machinery, bearing no sort of comparison with those realised in the cotton trade under similar circumstances. The chief portion of the benefit has, no doubt, gone to the public, in the shape of a greatly enhanced cheapness of the article; though it may be doubted whether the national wealth is much increased by the bushels of pins that must be swept away into dustholes every morning, after having been carelessly thrown away. Of the twenty-five tons of pins produced on an average every week, it is probable that at least twenty tons are absolutely wasted.

The pin itself being universally accepted as the very emblem of insignificance, not much is to be said regarding it. But the various stages in the history of its manufacture, with their accompanying vicissitudes, will be found replete with interest to the mechanical student and the economical inquirer, as illustrating the great ingenuity displayed in, and the important interests connected with "Great Manufactures of Little Things."

The metal pin, as an article of convenience or adornment, is of very remote antiquity. Isaiah, in inveighing against the frippery of the daughters of Zion, speaks of their crisping pins. Hair pins are referred to by Martial and by Juvenal as having been worn by the Roman ladies. Strutt, in his erudite work on the costumes of the English, makes mention of hair needles or bodkins as being used by the Saxons in the eighth century. It is nearly a matter of certainty that the making of pins, as a trade, found its way here from France in the reign of Queen Elizabeth, and that the first home of the manufacture was in Gloucester. So late as 1840, Gloucester continued to be one of the principal seats of this trade; nor was it until 1854 that it finally deserted that cathedral city for Birmingham, which now enjoys almost a monopoly of it.

It is proposed to take the reader through a manufactory of the old style, and explain to him the processes, which, though now out of date, will assist him in comprehending the difficulties surmounted, by slow and gradual degrees, in substituting for the skill of human fingers the automatic labour of machines of iron and steel. The successive mechanical inventions introduced into the trade with that object will be described in our next paper.

An important part of the old process was that of drawing the wire. Mill wire was not then delivered in a state of such high finish as at present, and the pinmaker had to perfect it before he could proceed. It is scarcely necessary to describe the operation. It consists in dragging the wire through tapering holes in a steel block, each successive hole being smaller than the last, thus bringing the wire gradually down to gauge, and lengthening it out. The wire being wound on to a drum or cylinder as it was drawn, was made up into bundles of a circular shape; and these bundles being delivered to the pinmakers, their first care, on unwinding them, was to straighten the wire preparatory to cutting it off in lengths. The method of doing this was apparently simple. The coil of wire was slipped on to a reel of conical shape, revolving easily round a pivot. The end of the wire was conducted to a block of wood, in which were stuck a series of pegs, arranged in a zigzag fashion, and the wire being threaded so as to pass on the outside of each, and afterwards between two rows of others set in line to act as guides, on being pulled through with a pair of pincers, came out perfectly straight. We have said *apparently* simple, because a great amount of skill and practice was required in setting the pegs, and their position had to be varied according to the thickness or hardness of the wire. A long shallow trough extended from the straightening block, and the workman pulled out the wires to the length of this, and then cut them off, the trough serving the double purpose of a length gauge and a receptacle. The wires were then cut into lengths sufficient for six pins, and, in that state pointed at both ends. The pointer sat before a spindle, carrying two circular files (one rough and the other smooth, and about the size of the little grindstones which form part of the apparatus of an itinerant razor-grinder) round at the rate of about 7,000 revolutions a minute. Taking a number of the wires between the thumb and fore-finger of his left hand, he rolled them backwards and forwards, while the thumb of the right hand pressed their nibs upon the file. Two turns upon each of the files were sufficient to make a clean and sharp point. A clever pointer could take up fifty wires at a time, and make 500 points in a minute. A pin's length was then cut off from each end of the wire, after which it was again pointed at both ends, again cut off, and again pointed, this time being cut through the middle.

The head of an old-fashioned pin consisted of a turn or two of very fine wire wrapped round the blunt end, forming a sort of knot. We may remember how it used sometimes to slip down the shaft, like the time-ball in the Strand. In order to form the heads, this wire was wound upon another wire of the same gauge as the pin, closely and evenly from end to end, about forty feet. Being then slipped off, it was chopped up into little coils of two or two and a-half turns by a sort of guillotine. The method of threading on the pins was primitive. A little boy put two or three handfuls of the heads into his apron, and taking half a dozen or so of pins in his fingers, worked them about in the heap until they threaded themselves by accident. The heads were afterwards riveted on by another operator by means of a little die, and a punch worked with a treadle.

The pins were whitened by means of boiling them in water with grains of metallic tin and a certain quantity of bitartrate of potash. The only remaining process was to stick them in the paper, of which the old-fashioned method was as follows:—The paper being rapidly doubled, after having been previously crimpled by a machine, was pinched between the jaws of a vice, just sufficient of the two folds being left protruding. The top of the vice was nicked transversely, to correspond with the two half rows of pins, and the girl having a heap of pins before her, raked up a few of them with a comb, thus getting the heads all one way. Laying these on the top of the vice, she rubbed them about until one lay in each of the nicks, when, brushing off the remaining ones, she gave a push with the back of the comb against the heads, and every pin entered the paper in its proper place.

PAPER AND CARDBOARD MAKING.—IV.

BY GEORGE TINDALL.

PAPER-MAKING BY MACHINE.

The process of paper-making is now divided into two totally distinct methods—that by hand, the old process; and the comparatively new and much more rapid process by means of the paper-machine, although the process of preparing pulp is the same for both methods of making. Paper made by hand is now almost entirely confined to strong and tough writing-papers for account-books, drawing-papers, bank-notes, loan-papers, etc. These papers being dried in sheets suspended on cords, shrink considerably while passing through this process, and thus acquire a tenacity unattainable in papers finished at machine, where the paper is dried on heated cylinders as soon as it is made, and in a continuous web; but by cutting the sheet, and afterwards sizing and drying in the same way as hand-mades, machine-made papers are made to approach them very nearly in many of their most valued qualities, and bid fair shortly to entirely supersede the older process.

The various materials being now judiciously mixed, coloured, and reduced to the finest possible fibres by the processes already described, and which may be considered as preparatory, these fibres are now to be converted into one continuous sheet of uniform thickness, and with as much strength and tenacity as can be given to it. Although the greater part of the paper made by machine is termed "wove," yet the method of making bears no analogy to the process of weaving by which woollen and cotton fabrics are made, in which the fibres are warped together into a continuous thread or yarn, and these threads are made to cross each other by a process similar to the darning of a stocking, and a continuous cloth is the result; the paper-cloth is made by the natural interweaving of the fibres as they settle together in the process of manufacture. Theoretically, if we place a quantity of paper-pulp with water in a flat tray or trough, the delicate fibres floating in the water will gradually fall to the bottom, interlacing each other in their descent, and forming a film or coating at the bottom of the trough; and if the water be drawn off without disturbing the film, or evaporated, and the film dried, a sheet of paper is the result; and practically this is what is done in paper-making, means being taken by machinery to remove the water and dry the paper as quickly as possible, and also to impart to it other necessary qualities not possessed by the simple film above mentioned.

Paper-making by hand, though still carried on in this country for the strongest descriptions of paper, is so far surpassed by the paper-making machine, that we shall describe the latter process first, referring to the former in our next article.

The diagram of the paper-making machine in the next page will enable us more readily to describe the various processes. It is drawn as simply as possible; the driving-gear, frame-work, and many of the bearings, being purposely omitted to show more distinctly the parts required for description.

The pulp being brought from the beating engines into the two large stuff-chests, A, is kept constantly agitated by means of a spindle furnished with cross-bars of wood, and driven by a bevel wheel over the centre of the chest. It is then raised by means of a pump into the small chest, from whence it flows into the mixing box, C; the quantity admitted being regulated by a tap. Three pipes open into this box, one conveying the prepared pulp, one bringing the back-water, as it is termed, from the machine—that is, the water drained away from the pulp, carrying with it some of the materials which are thus brought back to be used over again—and also a fresh-water pipe. In this box the pulp is mixed with the back-water, and, if necessary, with a quantity of fresh water also; and so mixed, flows over into a long wooden trough, D, called the "sand-catcher," from its having at short intervals along its course wooden projections from the bottom, in order to catch and retain the sand and heavier impurities which fall to the bottom by gravitation during the course of the fluid. It will have been noticed that in every process of preparation some means have been taken to separate and reject the dirt and other foreign matters necessarily mixed with the various materials used. This is of great importance, especially for fine papers, and too much care cannot be taken at every step; hitherto, however, the pulp has not been passed through a sieve, but this must be done before it is allowed to flow on to the machine. For this purpose it runs from the sand-catcher by means of the lips marked E into the trough, F, the bottom of which consists of brass plates cut with very fine slits called strainer-plates; the slits vary in breadth according to the quality of paper to be made, but for printings and writings they are very fine; and these strainers being kept constantly vibrating by means of a stud working on a ratchet-wheel, the clean pulp is passed through into a vat in which the strainers are placed, leaving the residue to be raked off and carried away.

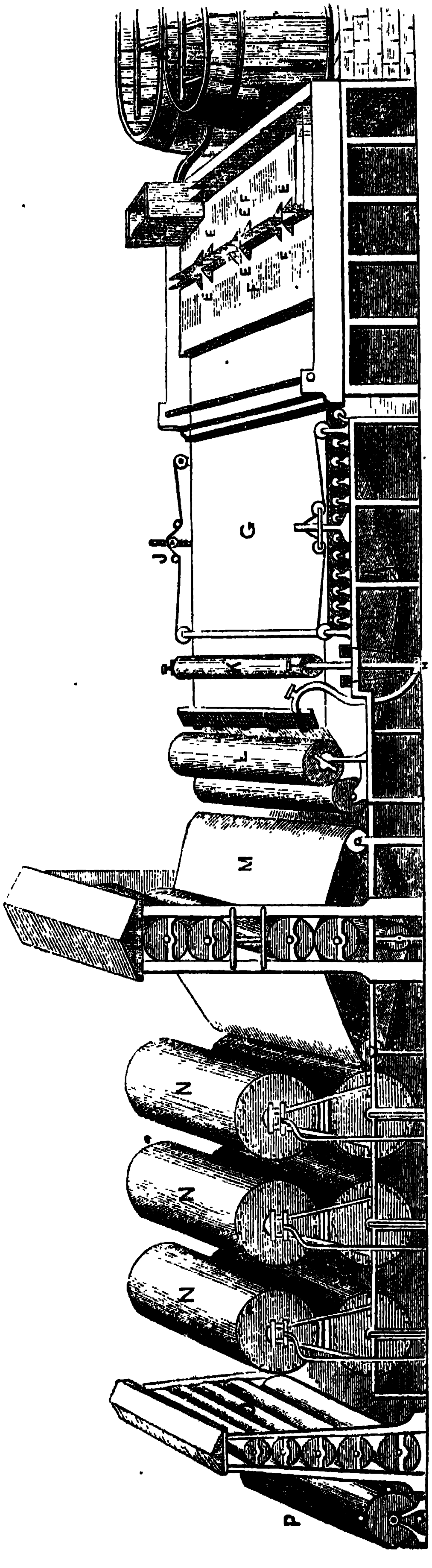
From the strainers the pulp flows in a broad stream on to the machine. It is received on an endless wire web, G, kept travelling over a series of rollers, and here the process of extracting the water at once commences. This portion of the machine is agitated from side to side by means of suitable machinery, and by this shaking motion the pulp is evenly distributed over the wire, and forms as it were a deposit upon it, a portion of the water passing through the interstices of the wire, the rollers underneath assisting in the withdrawal of the water. At H the wire passes over two broad boxes called suction-boxes, and here means are taken to draw a considerable portion of the water out of the pulp, by creating a vacuum in these boxes underneath the wire; this is done in various ways, the usual and oldest method being by means of a set of three air-pumps placed behind the machine, a continuous partial vacuum being kept up by the alternate action of the three pumps. For many papers, however, the vacuum caused by the fall of a column of water through a pipe communicating with these boxes, and passing down under the machine, is sufficient, the pipe being bent upwards again at the bottom to prevent the air from passing up into the boxes. A more effectual method is by injecting a jet of steam into this pipe, thus forcibly expelling the water quickly, and forming a more powerful vacuum. Loose ends are fixed into the boxes worked by means of a screw, and these are brought up to the edge of the mass of pulp flowing along the wire, and thus the air is prevented from entering the boxes through the wire, and only the portion covered with pulp is acted upon.

From the head of the machine to the first of these suction-boxes, the pulp has been in quite a fluid condition, and is prevented from spreading and running off the edges of the wire by means of a continuous india-rubber band about one inch square called a "deckle strap:" this is pressed lightly on to the wire by means of a brass frame-work, and it returns over pulleys as shown at J, motion being given to it by the wire so that they travel together. Between the two suction-boxes is placed the dandy-roll, K, and here the film having been formed on the wire, and sufficient water having been drawn out of it to leave it a firm mass, is begun to be manipulated; the dandy-roll presses lightly on the film as it passes underneath it, and revolving in union with the wire in the same way as the deckle-strap, it forms the upper surface of the sheet, the machine wire forming the lower one; it is also used to impress in the paper any letters or device called the water-mark, as any impression here given to the sheet is retained through the subsequent processes and appears afterwards in the finished paper. If a wove paper is required, the dandy-roll is covered with woven wire, same as the machine wire, and a paper uniform on both sides is the result; if a laid paper is being made, the dandy is made of longitudinal wires crossed with transverse ones about an inch apart; these wires press into the surface of the pulp, forming the well-known laid mark, the lower surface being the same as the wove paper. Letters and other designs are made of fine wire attached to the dandy-roll, and these designs, as they are impressed into the yielding pulp, become permanently fixed in the sheet of paper so formed, and cannot afterwards be erased without destroying the sheet. The wire with the sheet of pulp thus formed next passes over the second vacuum-box, where it is still further exhausted of water, the action here being considerably stronger than in the first, and then passes between a pair of large cylinders called "couch rolls," L, covered with closely woven woollen felt, where a considerable pressure is employed, to compact the pulp together into a close thin sheet, and squeeze out the remaining water. The felt on the upper roll is kept thoroughly saturated by a continuous stream of water flowing over the top of it, and kept from running off by a board pressed closely to the felt, and this prevents the paper, now completely formed, from adhering to the rolls, so that it still follows the course of the wire; but it is now sufficiently strong to be handled, and the wire being carried round the lower couch roll and returned to the head of the machine, the sheet is detached from it and carried on to a felt travelling round a wooden roll in front of the couch roll and a very short distance from it. The sheet is now called water-leaf, and resembles a sheet of blotting-paper saturated with water. The felt, M, now carries it between a pair of metal rollers, the upper one being very smooth and well finished, and here it is subjected to considerable pressure, and the side next the roll is rendered much smoother and finer, and from this roll it is carried to another felt passing between another pair of press-rolls, where the opposite side of the sheet is next the smooth surface of the roll, and thus both sides receive the same treatment.

The sheet of paper, if made from engine-sized pulp, and if great tenacity is not requisite, is now practically made, and it only requires to be dried and the surface made sufficiently smooth by calendering, to be ready for cutting and packing for sale. The drying is performed by passing the sheet over a series of metal cylinders, N, heated by steam introduced into one axis of the cylinder, and passing out at the other: small rollers of wood or metal placed near the cylinders conduct the paper, and cause it to cover as much of the surface of the heated cylinders as possible; and the drying is promoted in most machines by means of thick woollen felts, which are made to press against as large a portion of the cylinders as possible, and by means of which the sheet of paper is pressed closely to the cylinders, the drying being assisted by the heat of the felt itself. After being sufficiently dried the paper is passed through a series of highly polished and heavy metal rollers, O, for the purpose of receiving a finer surface, and in many cases two or more of these calender rollers are hollow and heated by steam to increase the effect. The paper is then either at once cut into sheets of the required size by a cutting machine placed at the end of the machine, or is reeled upon wooden rollers to be cut afterwards at a detached machine. The reeling apparatus, P, consists of a stand, on which four rollers are placed, the ends resting in bearers in a circular disc, and driven by a belt passing round a friction-pulley to prevent driving too fast and breaking the paper. When one roller is full the disc is turned a quarter round, and another roller is brought to the top of the disc; the paper is then broken and passed round the new reel, the old one being afterwards removed and an empty one substituted.

The general process of paper-making being now fully detailed, we will proceed to describe those modifications or additions to this process necessary to produce special descriptions of paper, and of these the most important is that of animal sizing, which is absolutely necessary for all writing papers. The most common way of sizing in the machine, is to place a vat or trough the width of the machine in a suitable position about midway between the drying cylinders: this trough is filled with size, which consists of the gelatine prepared from waste from the tanners, curriers, and parchment manufacturers, and the paper is carried through the size by means of rollers suitably placed, and it is then passed through a pair of rollers which press out the superfluous size, and proceeds at once to the second series of drying cylinders, the first three or four of which are skeleton-cylinders, inside which are a number of fans rapidly revolving, and thus causing a current of air to assist in drying the paper. A more complete arrangement consists in passing the sheet as it comes off the machine through a large vat of size, and then conveying it over a considerable number of skeleton-cylinders in a room appropriate to this purpose and heated by steam; the drying in this case is much slower than by heated cylinders, and the paper thus dried is harder and tougher.

An arrangement now often added to the paper machine, is to place a pair of glazing rolls—precisely similar to the calender-rolls before described, and heated by steam—before the last three or four cylinders. By this means the paper is subjected to the glazing process before it is thoroughly dried, and a much more highly polished surface is the result. This is generally adopted for fine printings and other papers where surface is of importance, as a substitute for plate glazing.



PAPER-MAKING MACHINE.

Ref. to Letters.—A, stuff-chests; C, mixing box; D, the sand-catcher; E, lips of sand-catcher; F, trough with strainer-plates; G, endless wire web; H, suction-boxes; J, pulleys carrying deckle strap; K, dandy-roll; L, couch rolls; M, felt; N, cylinders heated by steam; O, heavy metal rolls; P, reeling apparatus.

The number of drying cylinders attached to a machine is a matter of great importance, for unless the paper can be dried sufficiently fast, the speed of the machine is impaired, and the quantity of paper made in the time greatly lessened. The keen competition of late years has led to paper-machines being driven at a much higher speed than formerly, and an increased production from the same machines is the result. Formerly 60 or 80 feet per minute was the usual rate of speed; now many machines, especially on news, are driven at 130 and 140 feet per minute, and this must be perfectly dried when it reaches the end of the machine; so that it is not unusual to see fifteen or sixteen cylinders attached to a machine of this description. Formerly, also, machines of forty to sixty inches were the widest used; recently, many machines making paper over 100 inches in width have been erected; so that although the number of paper-mills is but little, if at all, greater than some years ago, the amount of paper made is very greatly increased.

Much discussion has lately taken place with regard to the best means of straining the pulp before it flows on to the machine, the method almost universally adopted being to employ two or more large strainers, of about six feet by two feet, and when the dirt strained from the pulp accumulates upon them, it is raked to one side and lifted out. This raking of the plates passes through them a considerable portion of the accumulated dirt, and foul paper at the time is the result. To remedy this, revolving strainers have been tried, and more recently strainers in which the pulp is made to flow across the plate in a rapid stream, the residue being carried by the wash off the plate, and further strained by means of an auxiliary strainer, and brought back to the mixing-chest. This is an excellent plan where one kind of paper is continuously made at the machine, but a better and more simple arrangement is to have a considerable number of small strainers in separate boxes, instead of two or three large ones, as the flow of pulp into any one of these can be stopped when the slits are clogged and the plate lifted to be cleaned, without passing any of the impurities collected on it into the vat.

For many papers where uniformity of surface is not of importance, the paper is not passed through the second pair of press rolls: this leaves the paper thicker and more bulky, but with one surface a little rougher than the other.

TECHNICAL DRAWING.—LVI.

GOTHIC STONEWORK.

EARLY ENGLISH ORNAMENTS.

THE most characteristic ornament of this period is that called the "dog-tooth;" but why it has obtained this name is not quite clear, since it is not much like a dog's tooth. It seems most likely that the name is derived from the dog's-toothed violet. It is, however, known as the "tooth ornament," and is really a solid rendering of the zigzag. It consists of a flower of four petals bent backwards, the division between the petals being placed in the middle of the sides of the pyramid thus formed, the pyramid itself being placed on its base against the hollow, with its apex projecting. This ornament varies to some extent in different examples, but always presents the same general appearance. Thus, Fig. 487 is the simplest form, whilst in the group of capitals (Fig. 479) the pyramid is perforated and ornamented.

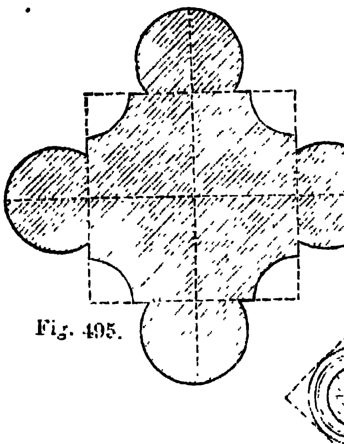


Fig. 495.

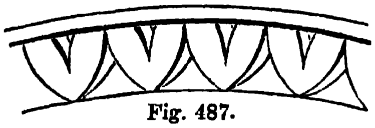


Fig. 487.

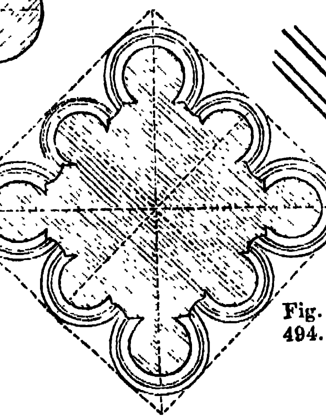


Fig. 494.

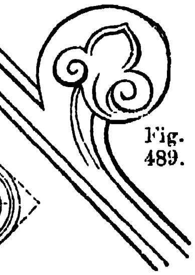


Fig. 489.

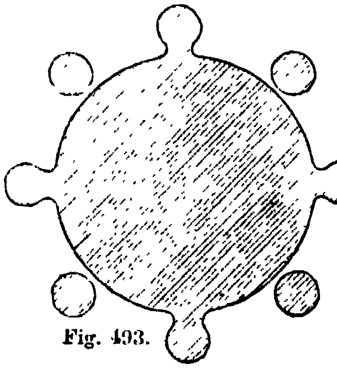


Fig. 493.

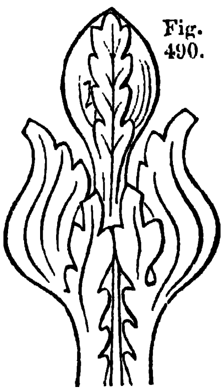


Fig. 490.

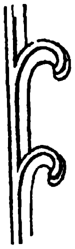


Fig. 488.

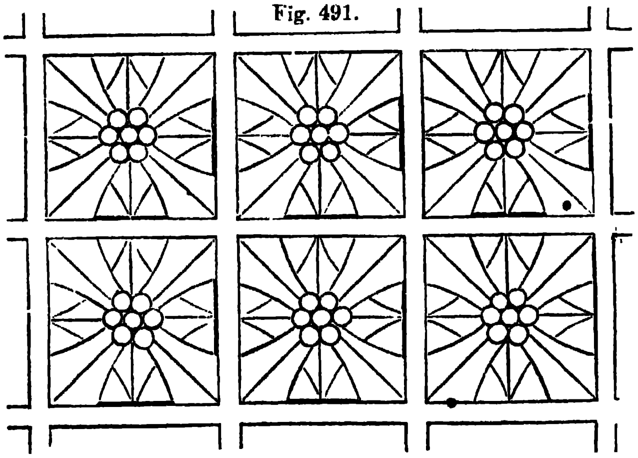


Fig. 491.

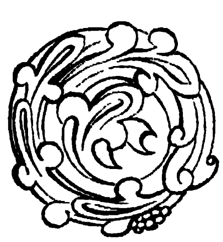


Fig. 492.

The position of the ornament is also shown in Fig. 484.

The crocket, the name of which is derived from the French *croc*, a "hook," is an ornament used to decorate the rib or edge running up the angles of spires, pinnacles, gables, canopies, etc. The crocket is supposed to represent the crook of a bishop's pastoral staff; and in this form one of the earliest and simplest is that shown in Fig. 488, taken from Lincoln Cathedral, which exhibits a simple curve turning backwards. Crockets of the Early English style are often simple trefoil leaves, and sometimes bunches of such leaves, placed at considerable intervals and curled backwards. Early specimens are to be seen at Salisbury (Fig. 489) and at Wells.

Finials (Lat. *finire*, "to finish") are, as their name implies, the finishing ornament at the apex of a spire, and consist, as it were, of a bunch of crockets. In the Early English period the finial was made up of foliage in character with the crockets and other features of the style. Fig. 490, from Westminster Abbey, is an illustration of this; and it will be interesting to compare the crockets and finials of this period with those of that which followed, the character of each being distinctly marked.

A beautiful method of ornamenting flat surfaces was prevalent at this and the subsequent periods originating during the Norman time: this was the manner of covering walls or portions of them with what has been called "diapering." The diaper usually consisted of a small flower or geometrical pattern, carved in low relief, the pattern being repeated in separate squares. One of these diapers (from Westminster Abbey) is given in Fig. 491, and the subject will be reverted to further on.

The character of the foliage of this period has been already referred to. The crispness of the leaves, not observable in other styles, although imparting a stiffness, still has a beautiful appearance, being worked with much taste and freedom. Amongst the varieties of foliage the trefoil is predominant; the two lower lobes, and sometimes all three, are worked with a bulb or swelling in the centre, the middle lobe being often larger than the others. Elegant scrolls of this foliage are often placed in the spandrils between arches.

The ornaments carved on the ends of the keystones of the ribs of groined roofs are called "bosses." The character of the ornamentation will be seen in Fig. 492.

If the transition from Norman to Early English was gradual, that from Early English to Decorated was much more so; and we have many curious examples of the different stages of the change. There can be little doubt that Early English was still in use in some parts of the kingdom—unwilling, as it were, to depart from the scene of its triumphs—at the same time that in other localities complete Decorated was becoming general; and thus the terms adopted to designate the different periods must not by any means be taken as definite, or as commencing and closing at any particular date, but merely as indicating the broad classification of the styles and details, and for associating them with particular reigns for convenience in study.

THE DECORATED PERIOD.

This style has been termed the "Middle Pointed" or the

"Edwardian" style, having had its commencement in the reign of Edward I., and arriving at maturity in the reigns of Edward II. and Edward III. It dates thus from about 1307 to 1377, or a little later, and may be named generally the style of the fourteenth century. This was the culminating period of all the beauties of Gothic architecture. It rivals the preceding style in chasteness and elegance, whilst it surpasses it in richness. The wondrous geometrical combinations in the ever-varying tracery; the foliage drawn direct from nature; the exquisite taste with which the construction was decorated, instead of being disguised, all tend to elevate it to the highest rank in mediæval art, and especially so since it is free from the extravagant and redundant ornamentation of the succeeding style.

There is no very novel feature in the arches of the Decorated period. The equilateral is perhaps, upon the whole, the most used, at least in early work; but the drop arch is constantly met with, and lancet, and even small semi-circular arches are found in window tracery, arcades, and niches.

There is, however, one form that may be considered as characteristic of the style—that is, the ogee arch. Although originally introduced into Gothic architecture at a much earlier period, it first came into general use in this country in the fourteenth century. From its constructive defects it is principally confined to the smaller class of work, such as arcades, niches, and the compartments of window tracery; it is also much used as a canopy over an equilateral or drop arch.

The arches of this period have one peculiarity by which they may be distinguished from those of the previous one—namely, that the mouldings frequently run continuously down the piers without being stopped by a capital. These continuous arch-moulds became still more common in the next period.

The shafts of piers in small parish churches are generally of a simple circular or octagonal plan, similar to those of the preceding period; and the capitals and bases must be examined in order to distinguish them. They differ from the Early English examples in being attached to, while in the previous style they were detached from, each other, and most frequently from the central shaft.

The plan of these clustered piers is often that of a lozenge, or of a square placed diagonally. Another shape is that of a quatrefoil; but others, too numerous to mention, are also found. In many instances we see four or more main shafts, with smaller shafts introduced between them. Fig. 493, which is the plan of a pier of the Decorated period, may be compared with Fig. 494 of the Early English and Fig. 495 of the Perpendicular period, the last of which will be described further on.

SEATS OF INDUSTRY.—XXI.

NEW YORK.

BY WILLIAM WATT WEBSTER.

NEW YORK, the most populous city on the American continent, and one of the most populous of modern times, is as pre-eminently the commercial metropolis of the New World as London is the commercial metropolis of the Old. The history of this great town will show that it owes its origin, its growth, and its prosperity to commercial enterprise, and to its natural and acquired facilities for carrying on trading operations on a gigantic scale. In 1609 the great English navigator, Henry Hudson, then in the service of the West India Company of Holland, explored the stream since known as Hudson River, and discovered Manhattan Island, on the southern extremity of which the greater part of New York is built. This island, then covered with rocky ridges of primitive gneiss, mixed with hornblende, slate, and mica, and showing evidence of violent upheaval, was, and, for a long period previously, had been in possession of the confederacy of Indian tribes called the "Five Nations," consisting of the Mohawk, Oneida, Seneca, Onondaga, and Cayuga tribes. Traces of a higher form of civilisation, however, than that of those Indian tribes at the date of its discovery, but not so advanced as that of the Toltecs or Aztecs of Mexico, have been discovered in the island and in its vicinity. In 1612 the Dutch laid the foundation of the city by establishing a station for the fur trade at the extremity of Manhattan Island, to which they gave the name of New Amsterdam, and in 1614 a rude fort was erected for the protection of the place. In the following year a settlement was formed at New Albany, on an island immediately below New York; but at this early period there existed no colony; not a single family had emigrated, and the only Europeans on the Hudson were the agents and servants of the Dutch West India Company. It was not till 1624, when Peter Minuits, the commercial agent of this company, brought over a few families, that any effort at colonisation was made. Peter was appointed governor, and retained that office till 1633. In 1626 this worthy managed to *purchase* Manhattan Island from the Indians for some twenty-four dollars! The cultivation of tobacco and the slave system were introduced before the year 1638. Towards the middle of the seventeenth century the colony was frequently harassed by the English and the Indians, and in 1653 a wall was built across the island to resist an anticipated attack from the troops of Cromwell. By the year 1656 New Amsterdam contained 120 houses and about 1,000 inhabitants. In 1658 wharves were constructed, and in 1662 the first windmill was erected. Four years after Charles II. ascended the English throne he granted the entire territory, of which Manhattan Island formed a part, to his brother the Duke of York, considering the occupation of the Dutch an act of usurpation. A small fleet was fitted out, and in August, 1664, the English took possession of the city, and changed its name to New York. For nine years it remained in their hands, but in 1673 the Dutch re-captured it, and re-named it New Orange. In the following year it was restored by treaty to the English, and kept by them till the close of the War of Independence in 1783.

The principal events and facts in the history of New York, during the period of its connection with Great Britain, may be briefly summarised. In 1686 James II. abolished the representative system of local government that had been established by the Dutch in 1652, and granted the city its first charter, which was confirmed by Queen Anne in 1708, and again confirmed, with modifications, by George II. in 1732. A colonial congress was held in New York in 1690; the city was lighted in 1696; a slave market was established in 1711; in 1725 the first newspaper, the *New York Gazette*, appeared; and in 1732 stage coaches were run to and from Boston and Philadelphia. What is known as the "Negro Plot" occurred in 1741-42. On the testimony chiefly of a servant girl, 13 negroes were burned, 20 negroes and one Roman Catholic priest were hanged, and 78 negroes and whites were transported, for alleged implication in a conspiracy to burn the city, which was never satisfactorily proved to have had any existence. In 1750 the first theatre was opened, and Colonial Congresses were held in the city in 1765 and 1776. A committee was appointed to resist the importation of obnoxious goods in 1770, but shortly after it was resolved to restrict the resistance to tea only. The statue of George III. was destroyed, and a marble statue of Mr. Pitt was erected in acknowledgment of the efforts he had made for a repeal of the Stamp Act. Two years later, when Pitt, then Earl of Chatham, had changed his policy, his statue was mutilated by the inhabitants. In 1774 the vigilance committee appointed to resist the landing of tea, stopped a vessel freighted with this article, and sent it back to England. Eighteen chests of the cargo that had been secretly landed were destroyed. After a battle on Long Island in 1776, in which the Americans were defeated, the British troops entered the city, and kept possession of it till the close of the war. In the same year a third of the city was burned to the ground, and two years later 300 houses were destroyed by fire. At the end of the seventeenth century New York consisted of about 750 houses, and its population consisted of about 4,500 whites and 750 blacks. In 1774, previous to the commencement of the revolutionary wars, it contained 22,750 inhabitants, and while the revolution was in progress its population remained stationary. The British evacuated the city, and Washington marched into it in 1783.

Since that period New York has increased with remarkable rapidity. In 1789 Washington was inaugurated first president of the United States at the New York Federal Hall, which occupied the site where the custom house now stands. A year later the population of the city numbered 33,131, and, notwithstanding a severe visitation of yellow fever in 1798, which carried off 2,086 of the inhabitants, by 1800 its population had risen to 60,480. In 1803, 1805, and 1822, New York was afflicted with yellow fever. But at the second of these dates its population had further increased to 78,770, and it may be mentioned that the Free School Society, the germ of the existing

Board of Education, was incorporated in 1805. One of the most interesting and important events in the industrial history of New York, or even of America, took place in 1807. In that year Robert Fulton plied the first steamboat on the Hudson, from a point near the city to Albany; and in 1812 he leased the ferries for 4,000 dollars, and ran steamers between New York and Brooklyn, a suburb on the opposite side of East River. Another great and destructive fire broke out in the city in 1811, and the war between the United States and England in 1812 for a time almost extinguished the foreign trade of New York. Its growth was checked, and the census of 1814 showed a decrease in the population. 1812 is also memorable for experiments with gas that were made in the park, and in 1814 Fulton's steam-frigate was launched. In 1823 a gas company was formed, and two years later gas was in general use throughout the city. The maritime and commercial importance of New York was enormously increased by the completion of the Erie Canal in 1826, which opened up water communication with an exceedingly fertile region, measuring 1,000,000 square miles, traversed by 2,500 miles of navigable water, and containing, at that time, a population of some 50,000, but which is now estimated at considerably more than 10,000,000. New York became the outlet for the produce of the Great West, which had previously been sent to Baltimore by the Susquehanna River, or to Philadelphia by the Schuylkill River. Up to the date of the opening of the Erie Canal, the exports from New York had been drawn exclusively from the regions of the Hudson River and Long Island Sound; since then a system of canals has connected the Hudson, not merely with Lake Ontario and Lake Erie, but with the Ohio, the Mississippi, and the Gulf of Mexico. In 1858 the Erie Canal brought to tidewater 1,496,687 tons of freight, including wheat and flour equal to 3,563,901 barrels of flour, nearly all of which came to New York. About the time when the Erie Canal was started the city was growing at the rate of 1,000 to 1,500 houses per annum. In 1820 the population amounted to 123,706, and in 1830 it was upwards of 213,000. Asiatic cholera caused 4,360 deaths in the city in 1832-34. In 1835 a great fire destroyed 648 buildings, and in 1837 trade suffered from a commercial crisis; but, notwithstanding all these afflictions, the population by 1840 had increased to 312,710.

The following decade witnessed the completion, in 1842, of the Croton aqueduct, one of the most extensive hydraulic undertakings of modern or ancient times. New York had previously suffered from the want of a proper supply of water, which was especially felt when the great and destructive fires we have mentioned occurred. The Croton water-works consist of a pond, enclosed by an embankment of stone and cement, 250 feet long and 40 feet high, which covers an area of 400 acres, and is capable of containing 500,000,000 gallons of water. The aqueduct for supplying this pond commences at a point five miles from the Hudson and forty miles from the City Hall. From the pond the water is conveyed through solid rocks and across valleys and streams, in an aqueduct constructed of stone and brick, in the form of a double arch, 8 feet 5 inches high, and 6 feet 3 inches wide at the bottom. It thus reaches Harlem River, which separates the northern part of Manhattan Island from the mainland, and it is then carried across this river by means of a magnificent stone bridge, 1,453 feet in length, consisting of fourteen arches, and 114 feet above the tideway, and conveyed, first to the receiving reservoir, covering thirty-five acres, and containing 15,000,000 gallons, and thence to the distributing reservoir, about three miles north of the City Hall. The minimum supply of pure wholesome water is estimated at 27,000,000 gallons per diem, and the works are said to have cost upwards of three millions of pounds sterling. Three years, however, after the completion of the Croton aqueduct, another fire broke out, which destroyed 546 buildings, and, in 1849, 5,071 persons died from cholera. During the latter year a most singular riot took place. The friends of the American actor Forrest, assuming that their favourite was displeased at the presence of the English actor Macready in the city, threatened to prevent him from appearing on the stage according to announcement. A numerously-signed requisition from the faction of playgoers that admired Macready, was presented to the actor, and he performed Macbeth at the opera house, intending that to be the first of a series of farewell performances. After the play was over a fight between the rival factions ensued outside the theatre, which had to be quelled by the military. Twenty-two lives were lost, and thirty-six persons were wounded in the *émeute*. Though assured of ample protection by the authorities, Mr. Macready made no further attempt to perform in New York.

The census taken in the year 1850 showed another extraordinary increase, the population at that date having reached 515,710, exclusive of the large suburb of Brooklyn, which, in the same year, contained 96,838 inhabitants. It was calculated that there were then in the city upwards of 80,000 persons employed in manufacturing and mechanical arts; the capital invested in these branches of industry was estimated at fully £6,000,000, and the annual produce at about £2,000,000 sterling. The Collins' line of steamers, trading between New York and Liverpool, was established in 1850; the Erie railroad to Dunkirk was opened in 1851; and the first city railroad was built in 1852. In 1853 an Industrial Exhibition, similar to the London Exhibition of 1851, was held in a crystal palace, 455 feet in length, and with an extreme breadth of 445 feet. By 1855, 19 daily and 126 weekly newspapers, and 78 other periodicals were published in New York. In 1857 there occurred a great financial panic, and a series of riots arising out of a difference between the mayor and the governor of the city, regarding the control of the police force, in the course of which eleven persons lost their lives. Important amendments were made in the charter of the city in this same year, and in 1858 they came into full force. The city was re-distributed into wards; the number of the aldermen was reduced from 22 to 17, and the councilmen from 60 to 24; the mayor and common council were deprived entirely of all control over the police, their salaries were abolished (but have since been restored), and their powers were considerably restricted, the issuing of licences for the sale of stimulants, in particular, being taken from them and vested in a special committee. Recent revelations have shown, in a striking form, that the local government of New York still needs to be radically reformed. The mayor and the heads of departments have salaries of 5,000 dollars per annum.

In 1860 the population of New York proper amounted to 805,551, and Brooklyn contained 266,667. In 1870 the total population of the city and its numerous suburbs and dependencies—Brooklyn, Staten Island, Jersey city, Hoboken, Mount Vernon, Astoria, Flushing, etc.—was estimated at considerably more than 1,400,000. A few items from the statistics of the trade and manufactures of the city in 1861 will show the extent of the most important of its industries at that date. There were then 454 establishments for the working of iron and metal, employing 11,480 persons; 253 establishments making wearing apparel, employing 19,541 persons; 6,049 persons were engaged in the chemical works; 4,912 in the leather manufactories; 4,912 in ornamental arts; 3,699 in making furniture; 3,139 in constructing steam-engines, etc. Shipbuilding has been carried to great perfection in New York, and since 1846 the construction of ocean steamers has been a speciality of the place. In 1851, 208 vessels (including 47 steamers, 11 of which were great ocean steam-ships) carrying a total of 71.214 tons, or nearly one-fourth of the whole tonnage built during that year in the United States, were constructed within the district of New York. In the same year the aggregate tonnage belonging to the port was 931,193 tons, or about one-fourth of the whole tonnage of the Union. New York Bay, or inner harbour, is one of the largest and finest in the world, being completely landlocked, and affording anchorage where all the navies in the world might ride in safety. The entrance to this harbour, called the Narrows, nowhere exceeds two-thirds of a mile, and is exceedingly beautiful, the shore on either side being wooded to the water's edge and studded with villages, farms, and villas. Rows of wharves and piers, the latter numbering about sixty, and averaging from 300 to 200 feet in length, and from 50 to 60 feet in width, extend along the Hudson and East rivers almost without interruption for an aggregate distance of seven miles. Ships of the largest size lie close to the quays, and proceed a great distance up the river. A few years ago it was estimated that the annual value of the merchandise loaded and unloaded in the port of New York amounted to about 500,000,000 dollars, and in the busy season the number of vessels in the harbour ranged from 1,000 to 1,500, exclusive of about 250 steamers. These figures would not represent the trade of the port now; it has since greatly increased. The imports comprise cottons, woollens, linens, iron, hardware and cutlery, earthenware, brass and copper manufactures, salt, etc., from Great Britain; silk, wine, brandy, etc., from France and Spain; sugar and coffee from the Havannas and the Brazils; tea from China, etc. In the year ending June 30, 1852, the exports were, of domestic produce, 38,853,757 dols.; foreign, dutiable, 5,333,572 dols.; specie, 37,273,703 dols.—making a total of 81,461,032 dols., or £16,292,205. The imports were, of dry goods, 48,900,935 dols.; other dutiable goods, 35,444,896 dols.; free goods, 11,926,912 dols.; specie, 2,528,391 dols.—total 98,801,134 dols., or £19,760,226. The duties collected in the port during the same year amounted to 28,678,910 dols., or £5,735,782, being considerably more than one-half of all the duties levied at all the ports of the Union. In 1858 the value of the exports from New York was upwards of 100,000,000 dols., being one-third of the whole exports of the United States for that year. The exports consist chiefly of wheat and flour, corn, rice, cotton, bullion, beef, pork, butter, dried fish, furs, lard, tobacco, and petroleum. In 1867 the total value of the exports to foreign countries, exclusive of specie, was 186,790,025 dols.; and in 1868 the total exports of specie to foreign parts amounted to 70,793,594 dols. In 1867, 4,676 foreign vessels, 2,053 being British, entered the port, and in 1868 the total number was 4,861, including 2,032 British vessels. Fully two-thirds of the immigrants who arrive in the United States land at New York. In 1854 the number who unshipped at this port reached the highest point it has yet attained, having been 319,223. The average annual number is about 200,000; in 1868, 212,989 immigrants landed at New York. Of the domestic commerce of New York it is difficult to form even an approximately accurate estimate, but some idea of its vastness may be gained from considering the necessities of its population, and the enormous quantities of produce brought thither by its canal and railway systems.

New York occupies an area of about ten miles in circumference. The main thoroughfare, called Broadway, is one of the largest and finest streets in the world, and the favourite promenade of the citizens. It is eighty feet wide, nearly three miles in length, and is almost straight. When the entire plan of the city is completed, this street will be about eight miles long. The part at present constructed contains many fine public buildings, palatial hotels, magnificent mansions, and splendid shops. Wall Street, the Lombard Street of New York, where the offices of the principal stockbrokers and bankers are situated, also contains several of the best public edifices in the city. One of the most notable features of New York is found in its monster hotels. Owing to the great distance between the places of business and the residences of most of the inhabitants, the custom of frequenting hotels and restaurants is all but universal. Large numbers of persons, married and single, moreover, permanently reside in hotels, and pay fixed weekly rates for their board and lodging. The oldest of the great hotels of New York is Astor House, in Broadway, erected in the year 1839 by John Jacob Astor, then the richest man in America. It is a massive granite structure, six stories high, with shops on the ground-floor. It contains some 600 rooms, and can accommodate 1,000 guests. The most expensive and luxurious of the New York hotels is the Fifth Avenue Hotel, an edifice in white marble, six stories high, which can also accommodate 1,000 guests. There are several other hotels in the city on an almost equally extensive scale. Among the most imposing public buildings deserving special notice is the New Exchange, built in granite, in the Grecian style, to replace the old Exchange burned in 1835. Including the price of the site, this edifice cost 1,175,000 dollars. The City Hall, which occupies a commanding position in the centre of the park, is 216 feet long and 105 feet wide; its front and sides are of white marble. It is entered by a flight of twelve steps, and by a double staircase which leads to a circular gallery, floored with marble; and above the whole rises a cupola, surmounted by a gigantic statue of Justice. The Common Council-room is very handsome. On the site of the old Federal Hall stands the Custom House, a marble edifice on the model of the Parthenon at Athens, approached by a flight of eighteen marble steps. The oldest educational establishment in the city is Columbia College, formerly called King's College, founded by George II., in 1754, which has a president and eight other professors, is attended by about 150 students, has a library of 25,000 volumes, and an estate valued at about 500,000 dollars. Attached to this college is a preparatory grammar-school, where about 300 scholars are taught. The University of the city of New York, founded in 1831 and opened in 1832, occupies a fine marble building in the English collegiate style. It has a chancellor and eleven professors, and its art students annually average about 150. The medical department has several professors and about four times as many students as the arts' department. There is in New York, besides, a College of Physicians, with six professors and a large number of students. The city contains several theological seminaries, prominent among which are the Union Theological Seminary, and the Protestant Episcopal Church Theological School. The Free Academy, a handsome Gothic structure built at a cost, inclusive of furniture, etc., of £16,000, now one of the most important high schools in the city, was erected in accordance with a vote of the citizens taken in 1846, for the purpose of extending additional gratuitous instruction to the former pupils of the common schools of the city and county. It has eleven teachers and some hundreds of pupils. There are numerous important literary, scientific, and artistic societies in New York; and it contains many excellent and extensive charitable institutions. Cooper's Institute, or the "Union," founded by Mr. Peter Cooper, at a cost of £62,500, comprises a free reading-room, picture gallery, art schools, etc. The Astor Free Library, founded by the American millionnaire of that name, contains upwards of 100,000 volumes; and New York can boast of several other large and valuable collections of books. In 1860, a woman's library, the first in America, was opened in New York. There are considerably more than 250 places of worship in New York, and many of them are costly and magnificent structures. Trinity Church, though only affording accommodation for 900 worshippers, and built in brown sandstone, cost £80,000. The Roman Catholics, the Presbyterians, the Congregationalists, the French Protestants, and the Dutch Reformers, all possess fine churches in the city. The Jews have twelve synagogues. New York is not particularly well provided with places of amusement, but it maintains several theatres, which are much frequented. There are eleven markets in the city. The streets are traversed by upwards of twenty lines of tramways, and splendid fast steamers run across the ferries to the various suburbs every few minutes during the day. Originally, New York was built of wood, and the streets were very narrow, but most of the old houses have been pulled down or burned, and replaced with houses of brick. The sanitary condition, and the paving and lighting of the city have been greatly improved, but it is not, even now, as a whole, on a level with most other large towns in these respects. The new streets are broad and regular, well paved and lighted, but in the more ancient and poorer quarters there is room for very great reform. In New York the practice of selling goods by auction, and especially goods imported from abroad, has long been in vogue, and is still a peculiarity of the city. Auctioneers there are appointed by the Senate, on the nomination of the Governor. Nowhere in America has banking been more abused, or has greater evils flowed from its abuse, than at New York. In 1863 there were no fewer than 309 banks in the city, organised on the security principle—the banks being obliged to deposit security proportionate to the amount of the notes they were empowered to issue. The publishing trade is very extensive. From the numerous presses of New York upwards of 250 periodical publications are issued, including, as it has been said, 19 daily, 126 weekly newspapers, and twelve quarterlies. There are thirteen German, two French, one Spanish, and two Welsh newspapers published in the city.

SANITARY ENGINEERING.—XV.

DRAINAGE AND WATER-SUPPLY.

In approaching this branch of our series we couple these two subjects for this reason, that the scope of our present space does not include *water-supply* in its most extensive and important engineering aspects; while at the same time throughout the country, with very few exceptions, the great proportion of the drainage—under which general head we intend to include all domestic appliances—is dependent for its efficiency upon a good supply of water. The course we therefore propose to take is in this paper to give a short summarised description of the ordinary methods available for obtaining an efficient supply of water for villages and small country towns; and in the next a similar sketch of the ordinary circumstances of what we may call metropolitan water-supply, as at present in operation in large towns, such as London, Liverpool, and elsewhere. And we may make the remark that one most important sanitary point to be kept in view is, that the water-supply shall be absolutely and entirely free from any connection with the drainage. A surface well of small depth, for example, in the neighbourhood of drains in an imperfect state is a most fertile source of disease, especially in what are called "cholera times," and the greatest precautions should always be taken to prevent any communication between the one and the other. There are other sources of danger to the public health, to which we shall only so far allude as to quote a single instance of the disastrous effects of impure water. During the last epidemic of cholera in this country, in one particular village 400 deaths took place within a very short period; and such a terrible disaster led to a scientific inquiry. It was found that the principal water-supply of the village was obtained from a well which was much in favour, because its water was bright and sparkling in its appearance. Chemical analysis, however, showed it to be highly charged with decomposed animal matter, and a careful examination showed that the only source from which this could possibly arise was that there was an underground drainage below the surface into the well from a neighbouring churchyard. This is, no doubt, an extreme case; but we quote it to show the great importance, in a sanitary point of view, of a pure supply of water. Into this particular branch of the subject, however, we do not go at greater length, and proceed at once to the consideration of the quantity of water required per head per day for all necessary domestic and sanitary purposes. We may remark that the quantity actually consumed varies very much in different localities. In healthy agricultural districts less water is really required than in confined and smoky towns. Authenticated returns show that the consumption at the town of Lynn, in Norfolk, is 50 gallons per day; while at Stroud, in Gloucestershire, 10 gallons only are used. This last figure may be taken practically as the minimum required; and we may mention that one of the first hydraulic engineers of the day recently made some observations by measurement of the quantity of water actually used day by day in his own house, which was fitted up with every convenience for comfort, and had more than one bath in pretty constant use. It was not a large mansion, but a gentleman's residence of moderate dimensions; and he found that the average quantity was 11 gallons per head per day. We may, therefore, take it that 10 gallons is a perfectly ample and sufficient provision, if properly available, for a general population. When we come subsequently to deal with the question of metropolitan water-supply, we shall find other disturbing influences at work, and shall have much larger figures to deal with. Our only object at the moment is to give some reliable data as to the quantity of water required for daily consumption, in proportion to the population of any particular village or district; though, of course, there is this advantage in a superabundant supply, that flushing and other operations in connection with a system of drainage can be more frequently and efficiently carried out.

We now turn to the various resources at command for village use, and how they are best available. A well, a stream, and the careful storage of rain-water are what we may call primary sources of supply, and neither of them is by any means necessarily insufficient. There are cases of country residences where the roof-area is tolerably large, and the constructional details well considered, where the rainfall alone, conducted by gutters and pipes to well-cemented cisterns underground, suffices for the entire supply of the house in all seasons from year to year; but these cases are exceptional, and we now take up the other sources from which a permanent supply can be ensured and laid on throughout a village. These may be divided into three:—First, a supply in the neighbourhood above the level of the village, either a stream or the rainfall from neighbouring hills. This supply is generally ample, but intermittent in the winter months, though there may be plenty of water for use all the year round; but this may not be available in the summer. What is requisite is manifestly a reservoir or means of storing the water; and to ascertain what the size of that reservoir should be, we refer to the figures we have last quoted as to necessary consumption, and assume for example that a supply is required for a village of 400 inhabitants. At 10 gallons per diem this gives a total annual consumption of 1,460,000 gallons, one-half of which should be stored for use in the dry months, allowing 50 per cent. for waste, evaporation, etc. Assuming a depth of 10 feet, the size of the reservoir should be about $\frac{4}{10}$ of an acre, and the cost of its construction may be roughly stated at £400. The supply being thus secured at a level sufficiently high to reach without difficulty the roofs of the houses, the laying on the water becomes a mere question of cisterns and plumbers' work, into the details of which we propose to enter upon a subsequent occasion. Financial questions —*i.e.*, where the money is to come from—are beyond our limits; but the question of rates, advances, outlay, and return or profit are obviously mere matters of calculation, after the first provision has been properly made.

In many cases, however, a reservoir at a level sufficiently high is not attainable, as the village itself may be situated upon the highest land in the district, and must therefore be dependent for its supply from below; and this brings us to the second branch of our subject, a supply in the neighbourhood a little below the general level—*e.g.*, a running stream. There, machinery to raise the water to the requisite height must be brought into play, and for this class of supply three different systems may be adopted—the hydraulic ram, the turbine, and the undershot wheel. The action of the hydraulic ram avails itself of the fall of a large body of water for a short distance, to throw a smaller quantity to a considerable height; and the profitable limit at which it can be employed, is when the height to which the water is to be lifted does not exceed twelve times the fall available. The fall to the ram should never exceed 20 feet, as then the strain upon the valves becomes too great. We cannot afford the space to explain at length in this paper the principles of the turbine and the undershot wheel, but only quote from a reliable authority some figures showing the comparative cost of the different systems, upon a parallel scale with the figures already quoted.

An hydraulic ram with a fall of 8 feet, and capable of raising daily to a height of 40 feet, and a distance of half a mile, 4,000 gallons of the same water by which it is moved, with a supply-pipe to the village half a mile long, but exclusive of connections with dwellings, etc., will cost about £360.

A turbine working with a fall of 20 feet, capable of raising 10,000 gallons daily to a height of 100 feet, with pumps and rising main for forcing the water to a distance of half a mile, but exclusive of connection with dwellings, will cost about £650.

A water-wheel capable of doing the same work as the turbine, but working with a fall of only 3 feet instead of 20, with pumps and rising main but no connections, may be taken at £750.

The peculiar circumstances and situation of the locality must determine which of these various methods of supply it is most advisable to adopt, when the source of the supply is a short distance below the general level of the village or town requiring it.

We now come to a third branch of the subject, and that is, when none of these resources are available, and the only course is to obtain what we may term a subterranean supply from a deep well. The facility of obtaining water by this means extends very widely over the country. On the greensand formations, the new and old red sandstone, and the lower outcrops of the chalk, there is a source which is practically inexhaustible; and the well being sunk, we have at our command various means of raising it to the surface—viz., wind, horses, and steam-power. Of these the wind is the cheapest, but as it is not always available, it is desirable to have the machinery so arranged that when there is no wind it can be driven by horse-power.

The number of days on which the horses would be required to work would vary, of course, with the locality, but perhaps 100 days throughout the year may be taken as a minimum; this result may again be modified by the construction of an intermediate reservoir large enough to meet the requirements of the various intervals. Where the depth, however, is not great, and the quantity of water required small, the old-fashioned revolving chain of buckets may still be used with advantage, as it can be readily repaired when required, and kept in order by any village blacksmith. For deep wells, however, force-pumps are required, with their attendant engineering appliances; and in many instances, especially in the coal districts, the introduction of steam will be found more economical than horse-power. Here again our limits admit of no figures in detail—steam-pumps and steam-engines, as applicable to water-supply, being literally legion in number, variety, and expense.

Having thus briefly indicated the various sources of supply for what we may call country districts, we may remark that in the erection of a house or mansion of any extent at a distance from any already existing source of supply, our previous remarks are applicable, and a sufficient supply of water should always be one of the points to which attention ought to be carefully directed. We heard lately of an extreme case where the question was thus raised late in the day. The proprietor called in a consulting engineer, who immediately reported that one cistern of 500 gallons contents was all that had been provided for the supply of a mansion where the daily consumption would be at least 3,000 gallons. Let us trust that similar cases are of rare occurrence.

Reverting to what we may call the general question, we may say that at the present moment the most important element in the drainage question, from a sanitary point of view—taking the kingdom generally, and what we may call the general practical position of these matters at the moment—is an ample supply of water. Other systems are in operation to a limited extent. We shall have occasion in the course of the current series to notice Moule's earth-closet, in which a totally different process is adopted, and the sanitary result to be obtained is arrived at—and successfully, as we believe, to a certain extent—by altogether different means. Other methods for the disposal of sewage are also in process of consideration by different public bodies; but taking the broadest view of the question, and the means at present at our command for evolving the best sanitary results from the appliances at our command, we may lay down the general principle, that the more ample the supply of water in any particular locality, the better conducted will be the drainage generally; as with regard to the removal of all objectionable material, the first and simplest process at our command is to *wash it away*. We therefore preface our papers upon the subject with this brief summary of the best available methods for village water-supply; and had we the requisite space at command, we might perhaps astonish our readers by showing in how many districts the facilities for water-supply above described are *not* available. In our next paper we propose to deal with the question of metropolitan water-supply considered from the same point of view, in relation to drainage; and then we shall venture upon the subject proper, as we may call it, and endeavour as best we may to give a technical description of the various mechanical appliances available "with an ample supply of water," *the first requisite* to maintain a perfectly healthful and satisfactory system of drainage.

BUILDERS' QUANTITIES AND MEASUREMENTS.—VI.

BY E. WYNDHAM TARN, M.A.

MASONRY.

Stone is used for the building of walls in a great variety of forms. The commonest kind of building is the rubble-wall, which consists of small rough stones placed together either dry or bedded in mortar; bond stones being introduced for the purpose of tying the two faces of the wall together. Rubble walling is measured either by the cubic yard, entering length, height, and thickness, in the dimension book under each other and cubing; or else the superficial area is taken, deducting openings, the thickness stated, and the quality of the work described as dry-walling, random-walling in mortar, coursed-walling, hammer-dressed on the face, etc. The bond stones are measured separately as cube stone, but their size is not deducted in measuring the wall. Where flints are used for walling, the dimensions are taken in the same way as for rubble walls, describing whether the flints are used rough, split, or worked.

Where the rubble wall has a thin ashlar facing of superior stone, the wall is measured as before described, and the ashlar taken separately by the superficial foot. If the ashlar is above 6 inches thick it must be cubed, and the labour on bed and face measured separately by the superficial foot; the same plan is to be adopted if the wall is built of solid ashlar, or hewn stone throughout.

In measuring hewn stone, take the cubical dimensions of each stone separately, as those of the smallest rectangular block which it could be got out of. Then measure separately the labour upon each face by the foot superficial as plain beds and joints, plain tooled or rubbed work, sunk work, circular work, sunk circular work, moulded work, circular moulded work; girting the mouldings in the two last items.

In measuring the labour in getting out the voussoirs of an arch, take one bed as superficial of plain bed, and the other bed as sunk work. The soffit is taken as superficial of circular work if left plain, and if moulded the moulding is girt and taken as superficial of circular moulded or sunk work; but if the moulding girts are less than 6 inches, take it as run of circular moulding in addition to the plain circular of the soffit.

When large stones are required which measure over 6 feet in length, they are taken separately and described as scantling lengths.

If stones have to be sawn in two, measure the sawn surface of each, and describe as superficial of half-sawing.

Spandril steps for staircases are usually got out by sawing a block such as A B F E (Fig. 3) in two, upon the diagonal line D C, so as to get two similar steps out of one block of stone. In measuring take the net cubical contents of each step, allowing ½ inch all round for working; that is, the extreme length A B by half the height A D. Measure the soffit as half-sawing, then the tread, riser, and soffit as superficial plain work rubbed, take the girt of the rebate at D by its length as superficial sunk work. If the step has a moulded nosing, then the riser must be taken as superficial sunk work, its width from the nosing to the rebate by the length of the step, and the girt of the moulding, by the length measuring round the return end, is taken as superficial of moulded work. The outer end of a spandril step is measured as superficial plain work, unless there is moulding, when it is taken as sunk work, and the moulding as above described. Number all mitres to moulded nosings, ends cut and pinned into walls, holes cut for balusters, etc. If there are winders to the spandril steps, they are measured in a similar manner, but with a greater allowance for waste, and the soffit is taken as superficial of circular sunk work.

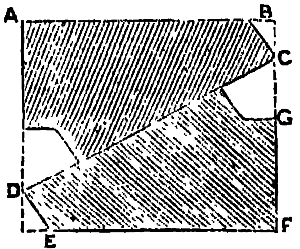


Fig. 3.

Landings that are less than 6 inches thick are measured by the superficial foot, and the thickness stated; if 6 inches and upwards, they are cubed, but kept separate from the other cubed work, and described as "cube landing." The labour on the top and bottom and outer edge is taken by the foot superficial as plain work rubbed or tooled, and any mouldings are girt by the length and entered as superficial of moulded work. Where the landings are formed of more than one length of stone, the joints are joggled, thus (Fig. 4): the joggle and its groove are to be girt and taken by the length of the joint as superficial of joggled joint. If one edge of the landing is cut and pinned into the wall, take its length as run of cutting and pinning; but if built in as the work proceeds, this is stated in describing the landing itself, and is not measured separately. Joggled joints to landings under 6 inches thick can be taken as running measure, describing the thickness of the landing in which they occur. If there is a throating to the landing, take its length as run of throating.

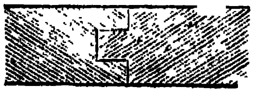


Fig. 4.

In measuring window sills, take the length by the width by the thickness, with an allowance for waste, as cube stone if not less than 6 inches thick; take the whole of the top as superficial of plain bed, measure the top, front, projection, and ends as superficial of plain work, and the sloping or weathered portion of the top as superficial of sunk work. For thin sills take the length only as running measure, describing the dimensions and work upon them; number the returned fair ends and all stoppings. Throating to sills is taken by the foot run. If the sill has a moulded front, its length is taken by its girt and described as superficial moulded work.

String courses are measured in the same way as sills, taking one plain bed and the projecting part as plain work, sunk work moulded work, as the case may be; number all mitres and stopped ends.

Cornices being generally formed of stones which bed upon the wall at least as much as they project therefrom, the exact width of stone must be ascertained and measured as cube stone, with proper allowance for the waste in working. If the stone has to be sawn, measure the face and back as superficial half-sawing. Measure the top and bottom beds where the stone rests in the wall, and also the ends of each stone, as superficial plain bed. If the top is weathered, take as superficial of sunk work the length by the width of the weathering. Girt the moulding, and take it by the length as superficial of moulded work. If there are grooves cut in the joints for running with lead, take their length as run of groove, the quantity of lead being taken by weight. Plugs and cramps are to be numbered; also number all mortise holes, notches, mitres, etc. Dentils, consoles, or other ornamental features in a cornice, must be numbered and described with a sketch showing the design, and their size given. If there is a blocking course above the cornice, measure its cubical contents as before described, take the superficial of the beds and joints as plain bed, the superficial of plain work to front and top, and half-sawing to the back; and any moulded work as before described. Number all plugs, cramps, etc., and take the run of grooves, and weight of lead used in running thereto.

In measuring stone columns, take the shaft separately from the cap and base, measuring the cube of each stone required in forming the shaft with allowance for waste in working; if there is a fillet and hollow included in the top and bottom stones of the shaft, the dimensions of those stones must be taken outside the fillet. If the shaft is got out of a single block, it must be so stated and the length described. Measure all the plain beds to the jointings of the shaft, and take plain work on two sides of the block; measure the circumference or girt by the length as superficial of circular plain work, unless the shaft has a curved outline or entasis, when it must be taken as circular sunk or circular moulded work. Girt the mouldings to the fillet and hollow at top and bottom by the circumference as superficial of circular moulded work. Number all dowels, mortise holes, etc. In measuring the capital and base, take the cubical contents with allowance for waste, measure the superficial of plain bed on the top, sides, and bottom of the stones, girt all the moulding by the circumference, and enter as circular moulded work.

Where the capital is carved, a sketch or description must be given, and the carving taken at each. Flutings to columns are taken by the foot run, and the stopped or rounded ends numbered.

Thin coping stone is generally taken by the foot run, and described as weathered and throated one or both ways, tooled, rubbed or quarry-worked, the width and thickness being stated. If the coping is more than 3 inches thick, take the cube of the stone and the superficial of the labour on the top, front, and projection, whether saddle-backed, weathered or otherwise, and take the run of the throating. Measure the plain work to one joint of each stone.

Moulded architraves are measured by taking the cube of the stone required for getting out, and the superficial of the moulded and plain work; numbering the mitres, dowels, plugs, stopped ends, etc.; and measuring one plain bed to each stone.

The quoin stones of building are cubed, and the superficial of plain work on the face taken; also the superficial of chamfered or moulded work, rustication, sinking, etc.; one plain bed of each stone being measured, and also the joints next the walling.

Flagged paving from 2 to 3 inches thick is taken by the superficial yard, and described as quarry worked, tooled, or rubbed. If edges have to be cut to paving, take the cutting by the foot run.

Paving with sets, as Elland-edge or granite, is measured by the superficial yard, the concrete bottom for the same being taken separately. Curbs are taken by the foot run, describing the quality, dimensions, and labour.

Sinks are measured by the foot superficial, their thickness stated, rebated holes and rounded corners numbered. Templates built into walls, stone core for cement cornices, slabs, and hearths, are all measured by the foot superficial, including the labour employed upon them, the thickness being described.

The labour to the tracery of Gothic windows is measured as superficial circular moulded work, taking the outline of the tracery by the girt, numbering all mitres and cuspings. Run the length of the groove for glass, and number the holes for saddle bars. The mullions are taken in the manner described for measuring columns.

Marbles used in slabs are taken by the foot superficial, including polishing. Cramps for fixing marble are numbered. Marble or granite columns are measured by the foot run, describing the diameter, and if diminished or curved. Marble chimney-pieces are generally numbered and described, but plain mantel and jambs are taken by the foot superficial.

FORTIFICATION.—VIII.

BY AN OFFICER OF THE ROYAL ENGINEERS.

DETAILS OF FIELD WORKS.

In the construction of works a knowledge of numbers of details is essential. Some of these, being mere matters of building and ordinary construction, will not be dealt with here; but there are others which, either from their connection with the artillery armament, or from their being universally employed by military engineers in the field, are necessary for any student of the art of fortification. The object of all fortification being to enable the defenders to use their weapons with the greatest possible facility and effect, the details of the works must be carefully designed to suit the armament for which they are intended; and it follows that whenever a new invention or improvement is introduced in either the guns, carriages, or projectiles, there must almost necessarily be some modification of the details of the work to adapt it to the new conditions. For this reason, details which to-day are necessary may in a short time become obsolete. Some of the details of field-works, however, are not liable to much change, from the fact that generally only certain materials are available in sufficient quantities in the field; and the methods of employing these are almost identical in most of the armies of Europe.

Revetments in Permanent and Field Works.—In order to economise interior space, and to allow of the free working of the guns, the interior slopes, the sides and ends of traverses, and the walls or sides of field powder-magazines are usually reveted. In permanent works the escarp and counterscarp of the ditch are generally massive walls of considerable height; and the question of revetments becomes one of the most difficult and expensive portions of the scheme. In field-works the slopes are seldom of any great height, and can be retained at a sufficiently steep inclination by any of the following materials—viz., fascines, gabions, hurdles, sods, sandbags, casks, planks.

Fascines.—A fascine (Fig. 53) is a neatly-made fagot of large brushwood, about 9 inches in diameter and 18 feet long, though it may be sawn off at a shorter length if required. In making a fascine, first lay out on the ground a rectangular space, 16 feet long by 4 feet broad, and at each end of it construct a low tressel by driving two stakes about 6 feet long obliquely into the ground so as to cross at about 2 feet 6 inches from it, the upper projections of the cross being about 2 feet long. These are then firmly lashed at the points where they cross, and a line is strained from one tressel to the other. Three other similar tressels are made between them, at 4 feet intervals, and lashed at the level of the line. The brushwood is then laid on the cradle so formed, all branches that will not lie evenly being removed; care must be taken that the brushwood is so laid on as to form a fagot equally thick throughout its length. The brushwood before being tied is compressed to the required size by means of an implement called a fascine-choker (Fig. 55), consisting of a pair of wooden levers 4 feet long, connected by a chain about the same length, on which two small rings are fixed 28 inches apart. The chain is placed round the fascine, and the levers are pressed down by two men until the rings are opposite to one another. Before the choker is removed, the fascine is bound or tied with wire, rope, yarn, or a twisted brushwood withe. Two men are employed binding, and commence about 9 inches from the end close to the choker. The fascine is bound in twelve places, at intervals of 18 inches, and the ends of the brushwood are sawn off so as to make it 18 feet in length. The size of the brushwood, and also the time of year at which it is cut, will affect the weight of the fascines, but on an average it is about 140 lb. They employ five men each, who should finish one fascine in an hour. Fascines are employed in various ways in the construction of works, and are a means of utilising brushwood for reveting purposes which would be too brittle for gabion or hurdle-making. A fascine revetment will stand at a slope of $\frac{4}{1}$, and is built as follows:—First dig a narrow trench, about 3 inches deep, along the foot of the intended slope, and in it place a fascine, which should be firmly picketed to the ground. The other fascines are then placed one above another, each row being picketed to the earth in the parapet and to the one beneath it, the earth backing being filled in and rammed as the revetment proceeds. In light sandy soil, or where the revetment is either required to stand for some time or is liable to be disturbed by the effect of the enemy's fire, a fascine, log of wood, or stout pickets should be buried in the heart of the earthwork, and attached by wire or lashing to one or more rows of fascines, so that they cannot slip forward without dragging this anchor with them. Fascine revetments last fairly well, but are somewhat tedious to make, as the parapet has to be formed simultaneously with the revetment; in addition to which it has the defect that if a fascine is displaced by the bursting of the enemy's shells in the parapet, not only is that particular one brought out of position, but probably all the other rows resting upon it are brought down also.

Other Uses of Fascines besides Revetments.—Fascines are generally used with gabions in forming a revetment, and are of great use in the formation of the roofs of blindages or other covered parts of field-works which have to resist the effects of shells falling on them. In road-making over marshy ground, and in the difficult and dangerous operation of crossing the wet ditch in the attack of a fortress, they form an important item in the materials required by the engineers.

Gabions.—Gabions are cylindrical baskets, with open ends, 2 feet in diameter and 3 feet high. They may be constructed of brushwood, sheet iron, or hoop iron. The ordinary brushwood gabion (Fig. 56) is thus formed—viz., three men are employed, one of whom prepares the brushwood; another holds the upright pickets, and takes care that the gabion as it proceeds is symmetrical and of the right size; while the third weaves the brushwood. A circle 11 inches in radius is traced on the ground, and ten or twelve pickets, about 3 feet 6 inches long, are driven in round the circumference at equal distances from one another. The number of pickets used must depend on the size of the brushwood, which if large will not bear being frequently bent. In the Prussian service the brushwood gabions are woven on the same principle as our iron band gabions, and have only seven pickets. Three long rods, stripped of small twigs and leaves, are then placed with their butt-ends resting each against a picket, and the weaving begins. Each rod is in turn taken outside the two pickets next it and inside the one beyond. This is continued until the gabion web or waling is 2½ feet high, care being taken to press the rods down on one another as the work proceeds. When a rod breaks or is too thin for further use, a fresh rod is inserted, its butt resting against the inside of the last picket touched by the one it replaces, and the two are then worked as a single rod. The ends of the gabion are now finished by two pairing rods, which after being well twisted, so as to prevent their breaking, are inserted one on either side of a picket, and are then woven alternately inside and outside the pickets, and over and under one another. Their ends are finally inserted on either side of the picket next beyond the point at which they began. The gabion may now be taken out of the ground, and after being similarly finished with pairing rods at the other end, the pickets are cut off at a height of about 1½ inches above the web, making the dimensions of the finished gabion 2 feet 9 inches in the web, and 3 feet from end to end of the pickets.

To prevent the web from slipping off the pickets when moving the gabions about, it is sewn as it is called, *i.e.*, brushwood withes or lashings of some sort are passed over the pairing rods in three places at each end of the gabion, and with each of these lashings three stitches are made as shown in Fig. 57, so as to bind the whole of the web together. A brushwood gabion weighs from 35 to 50 pounds, and takes three men about two hours to make. The hoop-iron gabion was first used at the siege of Sebastopol, owing to the difficulty of obtaining sufficient brushwood. It need not be described, as it has been much improved upon by Quartermaster Jones, R.E., who invented the iron band gabion (Fig. 58). This consists of ten bands of galvanised iron, each 6 feet 5 inches long, and 3 inches in width, having two buttons at one end and two slots at the other. The ends of the first band are buttoned together, and it is placed on its edge in a circle. Twelve pickets are then driven round the circle, alternately outside and inside it. The other bands are in succession buttoned round the pickets at the top, and pressed down on the bottom one. Two men can make one of these in five minutes, as they require no sewing.

They have the advantages of durability and lightness; moreover, as these bands can be so readily put together, they may be carried in bundles to the required spot, and made up there. Their defect is that they are liable to cause many wounds by their splinters if struck by a shot. Gabion revetments are built as shown in Fig. 59, and are generally used in the construction of siege-batteries and parallels, in preference to other materials, on account of the rapidity with which the revetment is built and cover obtained; moreover, when struck by shot the damage produced does not extend so far as in a fascine revetment, for instance. In building it, a fascine is first laid longitudinally along the foot of the intended slope; the gabions are then placed in a row touching one another, with their inner pickets over the centre of the fascine. This gives the requisite slope, $\frac{4}{1}$. The pickets are driven into the fascine, and the gabions are now filled with earth. A little care is necessary in first filling the gabions to prevent their being knocked over by the earth thrown at them when nearly empty; but practically very few men are required for this, and it is a great advantage to be able to get rid of the builders of the revetment when actually throwing up the earth, especially when the work is being carried on at night, and the earth is being obtained from the interior of the work, in which case it has to be thrown over or past the men who are building. When the parapet reaches the level of the first row of gabions, a fascine is firmly picketed on the top of them; and should a full parapet of 7 feet 6 inches or 8 feet be required, a second row of gabions is placed and filled. Gabions are sometimes used in road-making, to assist in forming drains; and in camps they may be usefully employed as a means of forming rough filters at places from which buckets can be filled without disturbing the mud in a stream. When so employed they should be sunk in the ground, and packed round with a foot or two of coarse sand, gravel, or brushwood.

Sandbags are very useful for revetments, because when empty they are very portable, and can be carried up in large numbers and filled at the required spot; they moreover require little or no skill to build, and enable batteries and parapets to be reveted and finished in places where no brushwood is to be had. The bags used in the English service are 2 feet 8 inches long, by 1 foot 4 inches broad when empty, and contain rather less than a cubic foot of earth. They are built in courses, as in brickwork, at a slope of $\frac{4}{1}$. Each row of bags is laid alternately as headers or stretchers, *i.e.*, if one row is laid lengthwise along the parapet, the next row above is laid with their length at right angles to the slope. Two men can build about thirty-five per hour, if the bags are filled and brought to them. Sandbags are of great use in the latter part of sieges, and also in the hasty defence of houses, etc., because two sandbags placed together are bullet-proof; and in the above-named cases protection from rifle-fire is what is principally wanted.

Sod revetments form a neat-looking slope, and stand at $\frac{3}{1}$; they are, however, tedious to build, and are not a very reliable means of retaining earth. They are laid in courses, like sandbags, each course being pegged to the one below it. They are usually cut 18 inches long, 9 inches wide, and 4 inches thick; but when built in revetment they occupy much less room, their number being generally estimated at five per square foot of revetment.

When hurdles or planks are used, they are kept in position by stout pickets, which should be anchored to something buried in the heart of the parapet, to enable them to withstand the pressure of the earth.

Traverses are mounds of earth thrown up inside a work, with the object of affording more protection to the defenders than would be given by the parapets alone. When they are intended to check enfilade fire, they should be almost as thick as the parapets themselves, and are usually reveted on the side which is not exposed to fire. In permanent works, and sometimes in field-works also, expense magazines, shell-rooms, or some other bomb-proof accommodation is provided under them; great care being taken to form the roof of railway iron, covered with fascines and earth, or with other material that will give the necessary security.

To protect the men working the guns in a work from the destructive effect of the shells bursting near them, it is necessary to construct splinter-proof traverses. These are generally revetted with gabions, and are about 16 feet long, and 4 feet thick at top. They are sometimes detached from the parapet, so as to allow the men to pass close to the parapet between the gun portions. One of these traverses used formerly to be placed between each pair of guns or mortars; but where economy of interior space is not required, this number may be advantageously increased.

In the approved type of screen-battery for sieges, a broad solid traverse, containing a recess or passage for filled shells, is placed between every gun or mortar; and in the Confederate batteries employed for the defence of Charleston Harbour each gun was isolated by having a traverse between it and its neighbours. The elongated shells of rifled artillery contain so much powder, and produce such powerful effects on bursting, that the necessity for numbers of traverses is greater than ever, and no work can be expected to continue its defence under their fire unless amply provided with them. A traverse which is intended to cover reverse fire is called a parados; and as these have frequently to be of considerable height, it is often impossible to allow sufficient interior space for them if made thick enough to really resist artillery. In these cases all that can be attempted is to construct them so as to screen the defenders from view.

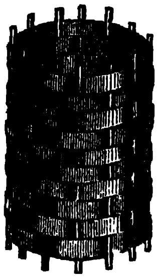
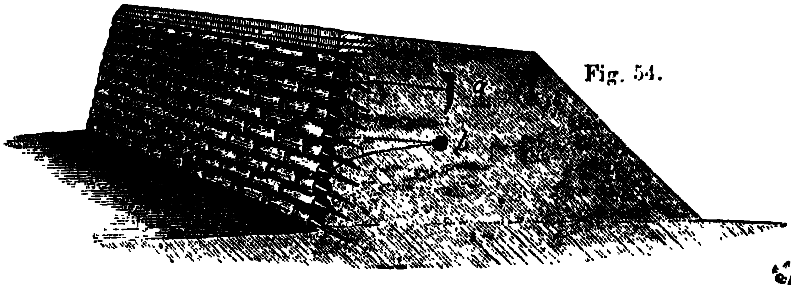


Fig. 58.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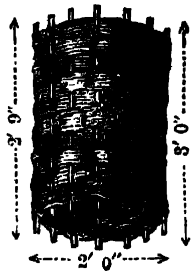
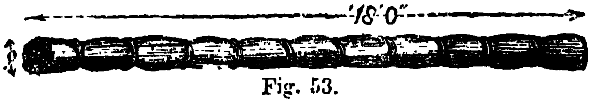


Fig. 56.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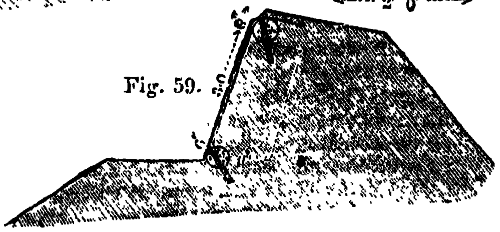


Fig. 59.

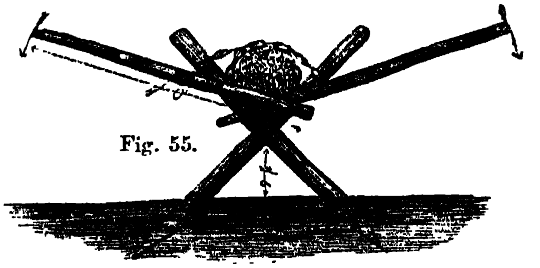


Fig. 55.

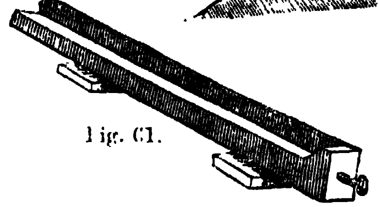


Fig. 61.

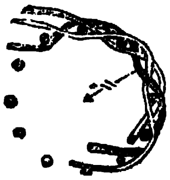


Fig. 57.

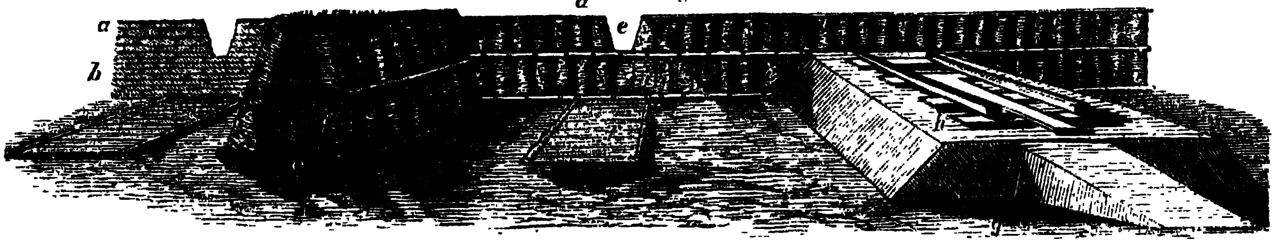


Fig. 60.

Fig. 53. Fascine. Fig. 54. Parapet revetted with Fascines (*a*, *b*, pickets and fascines used as anchors). Fig. 55. Fascine Choker. Fig. 56. Common Brushwood Gabion. Fig. 57. Plan and Method of Weaving Ditto. Fig. 58. Jones's Iron Band Gabion. Fig. 59. Musketry Parapet revetted with Gabions and Fascines. Fig. 60. Interior of Work, showing Splinter-proof Traverse, Platforms, and Revetment (*a*, sandbag revetment; *b*, fascine ditto; *c*, traverse; *d*, gabion revetment; *e*, embrasure; *f*, Pasley's gun platform; *g*, barbette for one gun; *h*, Colonel Clerk's platform; *i*, recess for powder or filled shells). Fig. 61. Enlarged View of Part of Platform at *h* in Fig. 60.

Platforms.—In order to facilitate the running up of the guns after their recoil, and to enable them to be readily traversed or moved from one side to the other, platforms of wood, stone, or iron are constructed, on which are placed the carriages or slides on which the guns are mounted.

In permanent works where heavy guns are employed, they are traversed from right to left on two curved iron ribs or racers let into granite blocks which are sunk to the level of the ground. There are three types of wooden platforms used in the field by our army, viz., Pasley's, Alderson's, and Colonel Clerk's (Fig. 60).

Pasley's platform (*f*) consists of a number of (five) sleepers sunk in the ground parallel to the line of fire of the gun; these are sunk nearly to the level of the ground, but slope upwards to the rear at $\frac{1}{18}$. On them a flooring of planks is laid, which in turn is secured by two side-pieces or ribbands, lashed or racked down to the sleepers. Pasley's gun platforms are 15 feet long and 10 feet 6 inches wide; and the mortar platforms 7 feet 6 inches by 5 feet 6 inches. Either of these can be laid by four men in an hour.

Alderson's platform consists of a number of balks of timber of the same size. Ten of those are bolted together in pairs, forming five sleepers, which are sunk as before; and on them the remaining balks are laid at right angles, to form the floor. The peculiarity is that all the balks are alike, and are bolted together with wooden dowels. They are 15 feet long by 9 feet broad for guns, and 9 feet by 7 feet 6 inches for mortars.

Colonel Clerk's platform (*h*) consists of two long beams or inclined planes, with flanged edges, up which the gun-wheels recoil. These are supported on a front and rear beam or transom and two sleepers, all of which are let into the ground, with their upper surface flush with it. The trail of the gun rests on a plank projecting to the rear from the centre of the platform. The inclined planes are 17 feet long, and are about 1 foot wide; and the whole platform can be put together in one hour by four men.

SHIP-BUILDING.—VI.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

DIAGONAL RIDERS AND FILLINGS.

It has already been remarked that the transverse frames of wood ships taken alone are, from the positions they occupy, necessarily ineffective against longitudinal bending strains, and that the most common evidence of structural weakness in such ships is their "hogging" or arching upwards. Ship-builders have tried various plans for strengthening the framing, some of which have fallen into disuse, while others are still employed. Of the latter, the two most important are "diagonal riders" and "fillings," both of which are due to Sir Robert Seppings, who was Surveyor of the Navy early in this century. There had, we believe, been previous proposals to use diagonal strengthenings upon the frames of wood ships, and some of them had been actually tried in France, but to Seppings belongs the honour of having carried the system to a successful issue, and given it the form that it still retains.

Supposing a ship to be hogged, the ends must have drooped relatively to the middle, the upper parts must have been stretched, and the lower parts compressed. If, therefore, it were possible to strongly tie the ends of the ship to the middle, and to make the lower part capable of resisting great compressive strains, the resistance to hogging would be much increased. Seppings used diagonal riders for the former purpose and fillings for the latter. He illustrated the usefulness of the riders in a homely fashion, by referring to the rigidity of form given to an ordinary field-gate by means of the diagonal piece fitted from the upper angle at the side nearest the gate-post, to the opposite angle of the gate, and it will be easily seen that there is a great resemblance between the conditions of strain in the gate and those of the ship which tends to hog. The side of the gate farthest from the post tends to droop, and would droop if the gate were formed only of vertical and horizontal pieces, because these would be capable of offering but little resistance to a change of form from the rectangular to that of any other parallelogram. When the diagonal piece is fitted, however, it directly opposes any such change; for it will be obvious that in order that the rectangular form may be altered into that of any other parallelogram, the length of its diagonal must be changed. If two diagonals were fitted, still greater strength would of course be gained, because, while one resisted tension the other would resist compression.

Seppings carried this idea into practice, at first, by fitting strong and massive timbers, or "riders," inside the frames, and placing them at an inclination of 45°, with their heads sloping towards the centre of the ship, or "midship section," so that those in the fore-body were inclined in the opposite direction to those in the after-body. Besides those riders, complementary pieces, named "trusses," were fitted, also inclined at 45° to the vertical, but in the opposite direction to the riders adjacent to them; and in addition the internal strengthenings included thick longitudinal strakes of planking, overrunning and bolted to the riders and trusses. The plan was elaborately worked out, and it added much to the strength of ships, so that it attracted much attention, both in this country and abroad. It had, however, some disadvantages; unavoidable, perhaps, with wood, but still of consequence. The chief were the difficulty and expense of construction involved, and the great loss of space in the interior; but in spite of these objections, the plan continued in use in the Royal Navy for some years. The latter objection, loss of hold-space, induced Seppings to suggest that in small vessels, where such a loss would be most serious, iron riders might be used instead of wood, and it was not long before the advantages of the change led to the use of iron riders in larger vessels also. At present, timber riders are not used in British-built ships, but in American-built ships they have been occasionally used up to comparatively recent times, the abundance of timber in Canada and the United States probably being the chief cause of its continued employment.

The iron riders now in use are formed of long narrow plates (usually from 4 to 6 inches wide, and from ½ inch to 1 inch thick), placed diagonally, as shown by *r r* in the elevation in Fig. 15 (page 81). Their upper ends are generally situated near the height of one of the decks, and the lower ends near the first head, where the form of the frames amidships is getting flat. Like the timber riders they have replaced, they are so arranged as to have their upper ends inclined towards the midship section in both bodies; they are also usually allowed to cross one another for a short distance amidships. This arrangement is specially suited to iron riders, because it brings them into *tension* when the ship hogs, and they are capable of bearing considerable tensile strains, while they could not resist compressive strains. In some ships, however, the riders have been arranged on the opposite plan, with their heels pointing towards the midship section, and consequently they have not been nearly so useful as they should have been. If only one set of riders is fitted in each body, then they should be placed so as to resist hogging most efficiently; but if, as is sometimes the case, two sets, crossing each other at right angles, are fitted throughout the length, greater strength is undoubtedly given to the structure, and sagging as well as hogging strains are provided against. This duplicate arrangement is not often adopted, nor is it commonly required, but it has been carried out with advantage in many of the large wood ships of the Navy, and especially in some of the iron-clads. In the latter both sets of riders have been worked upon the frames, and bolted through them and the outside planking; but in the older wood ships it was common to have the second, or subordinate set, fitted inside the "ceiling" (or inner planking), and not to continue them above the height of the lower deck. A suggestion has been made, and we believe it has in a few cases been carried out in practice, that it would be well, while retaining the usual arrangement of a single set of riders at the bow and stern, to have a double set for a portion of the midship length. Such a plan would have the advantage of making the midship part strong against sagging as well as hogging strains, as it obviously ought to be, while it would leave the ends strong against hogging strains, to which they are especially subject.

The practice of the Government service is to fit the riders *inside* the timbers of the frame (as shown by *r r* in Fig. 15); that of the private trade is to fit them *outside*. Both plans have advantages and disadvantages. For facility in carrying on the work the Government plan is to be preferred, because the inside of a ship in frame is comparatively clear when the riders are fitted; whereas on the outside there are necessarily ribbands and harpins, to support the timbers in their proper positions, portions of which must be cut away or otherwise removed in order to fit the riders. On the other hand, the balance of advantage in point of strength lies with the private practice, although the balance may be small. A rider fitted outside and well secured at the ends, naturally lies close to the convex surface of the timbers; and when subjected to tensile strains is brought still closer, so that its friction on the timbers would probably be considerable, and the bolts fastening it to the timbers would be but little strained. A rider fitted inside, on the contrary, can only be held close to the concave surface of the timbers by the bolts, and its tendency to spring off from the timbers must be increased when it is subjected to tensile strains; so that under such circumstances the bolts have to bear nearly the whole strain, and receive little or no help from friction. In short, in the one case the timbers themselves mainly keep the rider to its curvature, in the other the bolts have to do the work, and enable the rider to develop its tensile strength. Whether fitted inside or outside, however, riders are important strengthenings to a wood ship, and they are particularly useful in assisting the outside planking to develop its strength. Besides this, they afford a good connection between the various parts of the framing, and indirectly add much to its transverse strength.

Sir Robert Seppings' system included also the use of "fillings" between the lower timbers of the frame. His object in proposing such an arrangement appears to have been twofold—viz., to add to the safety as well as the strength of ships. The sketches in Figs. 14, 15, 16 will illustrate the present mode of fitting these fillings in ships of the Navy. From Fig. 15 it will be seen that the fillings extend to a height rather greater than that of the third sirmark, and that they entirely fill the openings between the frames up to that height. The sectional view (Fig. 14) shows by a dotted line the shape of the filling, which gradually diminishes in its depth, or "moulding," as compared with the timber; this is done in order to form a "water-course." When fitted in place, the joints are carefully caulked, both inside and out; and it is this which adds to the safety of the ship, because injury to the bottom planking does not necessarily cause the entry of water into the ship. In some cases this consideration has led to the extension of the height of the fillings as far as to the load-water line, but the practice is not common, nor does it seem a desirable one, seeing that injury to the planking is much more likely to take place below the height to which fillings are usually carried than above it. The gain in strength is not less important than that in safety; and it is due to the fact that the fillings render the lower part practically solid, and as incompressible as the material will permit it to be, so that the resistance to hogging strains is greatly increased. Without fillings the massive transverse framing would have no opportunity of developing its strength to resist compression, but with them the conditions are entirely altered. Hogging does, it is true, take place to some extent, even in wood ships with fillings and riders; but this may be explained by the fact that the longitudinal strength of the upper portions of such ships against *tensile* strains is deficient, rather than by the assumption that the lower part is incapable of bearing compression. Experience bears this out; working in the upper works of wood ships is far from being uncommon, but it is seldom one hears of any symptoms of weakness displaying themselves in wake of the fillings.

The use of fillings is not common in merchant ships, and the fact is rather to be regretted; but it probably is of minor importance now, seeing that only vessels of comparatively small size are likely to be built of wood. Against sagging strains fillings are not, of course, effective, nor do the lower timbers lend any material aid in resisting such strains, which would consequently have to be borne by the bottom planking, keel, keelson, etc. These are not the strains, however, which experience shows us to be the most injurious to wood ships; and while a ship with fillings is no worse off under these circumstances than one without, she has a great advantage when subjected to hogging strains.

The openings have in a few vessels been filled in very nearly from gunwale to keel, the framing being thus turned into a compact mass of timbering connected together by dowels and bolts. The weight of the framing is, of course, made much greater by this arrangement, and it is only had recourse to when very exceptional strength is required. In ordinary vessels partial fillings are required for special purposes in some parts—such as in wake of the channels, scuttles, etc.—but these do not add to the strength of the structure, and are not intended to do so.

OPTICAL INSTRUMENTS.—XVII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

Condensed Gas System.—Undoubtedly the usual arrangement of gas-bags, pressure-boards, and weights is a cumbrous one, though presenting advantages to the travelling lecturer in other ways; and though the water-pressure arrangements dispense with the impedimenta of weights, while the lecturer is travelling, they still present bulky and unwieldy packages. The Americans have lately advocated the method of condensing the gases in metal bottles, as presenting the advantages of compactness, extreme portability, and economy, *with the greatest amount of pressure attainable;* which, in other words, means security from the gases mixing, running back, and exploding—as *the weights* may be said *to be always on*—and also increased intensity in the light produced. Thus the gases may be kept at hand any length of time, and ever ready for use, which is not the case when they are stored in india-rubber bags. As regards comparative space occupied, while *a single* gas-bag of 6 cubic feet capacity within its pressure-boards would measure more than 36 by 24 by 24 inches when filled, and its weights 17 by 6 by 5 inches, *a pair* of bottles each of 6 cubic feet capacity would only occupy a space of 30 by 12 by 6 inches when packed in a stout travelling-case (Fig. 61). As regards comparative price, a stout gas-bag with pressure-boards and weights would cost £4 14s., while a bottle in case would only cost £3 3s.; and the bottle will not wear out, while the gas-bag must every now and then be replaced. As these bottles must be sent to the manufacturers to be pumped full, the cost of the generating apparatus is also saved. This leads us to the only drawback to the system: the pumping apparatus is costly, and requires great care in manipulation; in fact, the only danger in this system occurs at this stage of filling. But though this is a drawback to those who have to lecture night after night, the amateur would regard the saving him the trouble of making the gases as an advantage; as he has only to make a point of returning the bottles to be re-filled immediately after each exhibition to obviate this drawback, especially as he can obtain the gases cheaper than he can make them himself. To the photographer this form of apparatus presents great advantages for enlargements, being ever ready for use. But this system is not a new one, for it was employed twenty years ago by Mr. Adams, the well-known lecturer on astronomy and physics. These bottles consist of wrought-iron cylinders, 27 inches long by 4½ inches in diameter, capped with most carefully-constructed valves worked by lever regulators, and are capable of holding 6 cubic feet of condensed gas. These are tested before sale to sixty atmospheres, or a pressure of 900 lb. on the square inch, and as the pumping pressure seldom exceeds twenty-five atmospheres, or less than half the test pressure, perfect immunity from danger is ensured. *À priori*, we should fancy that as the pressure is always on the decrease, the light would also be decreasing, unless the valves were under constant regulation; but practically this does not happen; for, if properly manipulated, we have not to alter the taps more frequently than with the gas-bag arrangement. Six cubic feet bottles will last two hours, though by careless working they might be used up in twenty minutes, or even in as many seconds.

On connecting condensed gas-bottles with a lime-light jet, the taps of the jet should be turned full on, and never used, all adjustments being made direct by the lever-keys that regulate the valves.

Lime-Light Jets.—Lime-light jets are divided into two classes —"oxy-calcium jets," wherein the oxygen is completely isolated from the spirit or house-gas flame through which it is blown; and "oxy-hydrogen jets," where the gases are stowed in separate bags or other receptacles, and mixed in a tube just before passing from the nozzle. Oxy-calcium jets are again distinguished as "oxy-spirit-jets" or "oxy-house-gas jets."

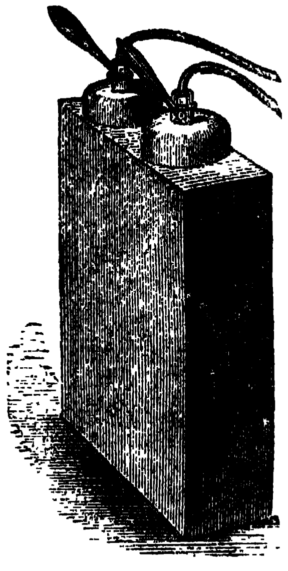


Fig. 61.

Oxy-spirit Jets.—For "foreign service," or in country places when house-gas is not attainable, a good oxy-spirit jet is a most useful form of apparatus—in fact, the best form that can be recommended for such localities. The ordinary form is shown in Fig. 62: it consists of a "fountain-lamp" cistern capable of holding half a pint of methylated spirits of wine, S; the spirit is carried to the wick, W, by a tube terminating in a cylindrical wick-holder. The wick is ordinary lamp-cotton, about 2¼ inches in length, and about ¼-inch in diameter, passed through three tubes arranged triangle fashion (one wick next to the lime, two next the nozzle). When trimmed the cotton stands about ¼-inch above these tubes, and the entire wick is divided and bent back right and left, so as to leave a clear course for the oxygen to the lime, care being taken that no stray threads touch the nozzle or lime-cylinder. Beneath the spirit-tube runs another tube, O, that carries the oxygen gas from its receptacle to and through the centre of the spirit-flame, and on to the lime-cylinder, L, by an upward curve terminating in a blow-pipe nozzle, N.

The wick must stand at a proper height in relation to the fountain valve, or the spirit will overflow and cause accidents. Both careful construction and manipulation of this arrangement is necessary to prevent such a mishap.

In the *Journal of the Photographic Society* for December 18th, 1869, page 168, Dr. D. Van Monckhoven describes and figures a modification of the oxy-spirit jet, wherein the spirit is placed in a deep upright cylindrical spirit-lamp, but exception must be taken to the length of the spirit reservoir, as entailing too great a strain on the capillary powers of the cotton fibres, for the shorter the wick the fuller is it charged with spirit, and the liability for the wick to char is lessened.

M. Romain Talbot of Paris has arranged an oxy-spirit jet, so that the oxygen is projected through the centre of a cylindrical wick, nozzle and wick being concentric. By one arrangement the jet is projected on the lime in the usual angular direction. In another the oxygen jet shoots straight upwards through a wick formed of a bundle of fine wires, and the oxy-spirit flame is projected on a disc of soft lime placed at an angle to the perpendicular jet.

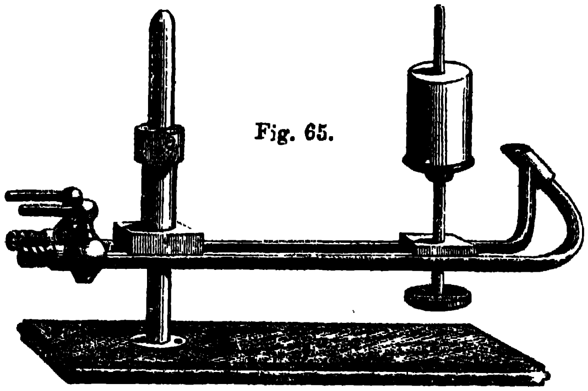


Fig. 65.

Convinced as I am of the value of the oxy-spirit jet for localities where house-gas is not attainable, and the making of pure hydrogen would be regarded as an insurmountable objection to the use of lime-light apparatus, I have modified the usual form of this jet, and I think it will be found with advantage. The points of construction are:—

1. A reservoir for the spirit that can be kept cool and cannot overflow.
2. A wick that gives a large compact flame.
3. A wick-holder that will keep the cotton wick so cool that it cannot char.
4. A support for the lime-cylinder that of necessity need not have an adjustment to and fro, if the lime-cylinder be turned to one gauge of a given diameter.
5. A large-bored blowpipe nozzle, for which an adjustment to and fro in the flame is an advantage, set at such an angle that it makes the rays from the incandescent lime clear the tube that carries the nozzle, so that its image may not be projected on the screen by the condensers.
6. The means of adding more spirit, should it run short, without having to extinguish the burning wick or disturb the adjustment of jet in its lantern.

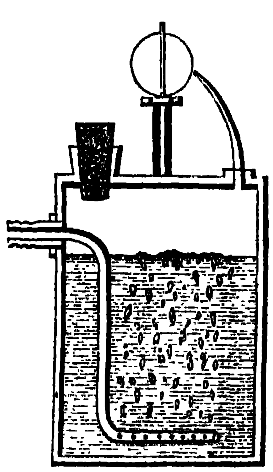


Fig. 68.

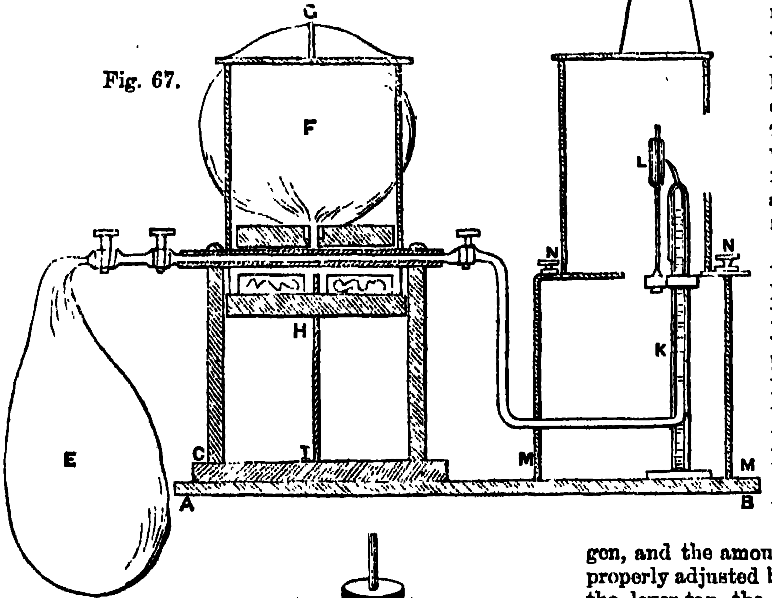


Fig. 67.

My oxy-spirit jet is shown in Fig. 63. It will be seen that the reservoir, R, is a horizontal cylinder (not upright as in Monckhoven's) somewhat resembling a steam-boiler in aspect, but is in fact a shallow spirit-lamp, wherein the arrangement of the wick and its holder is the important point of modification. Instead of being round and small, the wick, W, is long, wide, thick, flat and double, and is made of loosely plaited cotton, not cotton thread. The wick-holder, H, is made of thin sheet brass (to hold as little heat as possible), and is ¾-inch in the side by ⅛-inch wide, and the top is cut obliquely to form an angle of 25°. This is fitted to the top of the spirit-lamp by a stout tubular fitting that allows of the wick being adjusted for height and direction. The wick is evenly trimmed to correspond with the angle of its holder, and is then divided and turned on each side to form a clear valley through which the oxygen is projected on to the lime. The reservoir is supported on a tube, O, that supplies oxygen to the flame, and this tube is attached to an adjusting clamp, C, that slides on a supporting rod. Into the end of the oxygen tube a blowpipe nozzle of large bore, N, fits so that it is adjustable to the wick for height, insertion, and true intersection of the spirit-flame, and it is set at an angle corresponding with that of the wick. At the back of the reservoir is fitted a screw-capped tube, T, by which fresh spirit can be added while the lamp is burning.

A rotating lime-support, L, is attached to the tubular fitting into which the wick-holder slides. To keep the spirit cool, a current of air is admitted to the reservoir by holes in the screw-cap, T, and the wick-holder H. By the arrangement here described, the wick-holder will keep so cool that it can be easily handled while the wick is alight. When connected with a supply of oxygen, and the amount of gas is properly adjusted by means of the lever-tap, the spirit-flame is carried in a noiseless jet upon a soft lime-cylinder that soon yields a bright disc of light, and with full pressure the best light I have ever seen got out of an oxy-calcium jet. In conjunction with a portable metal gas-holder this fully meets the requirements of an Indian or colonial outfit, whether it be for photographic enlargement or lantern exhibitions.

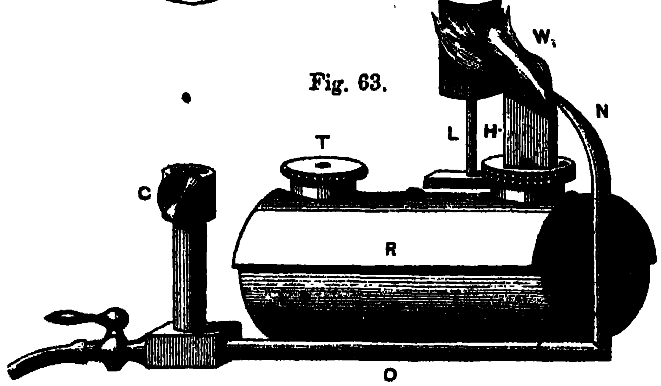
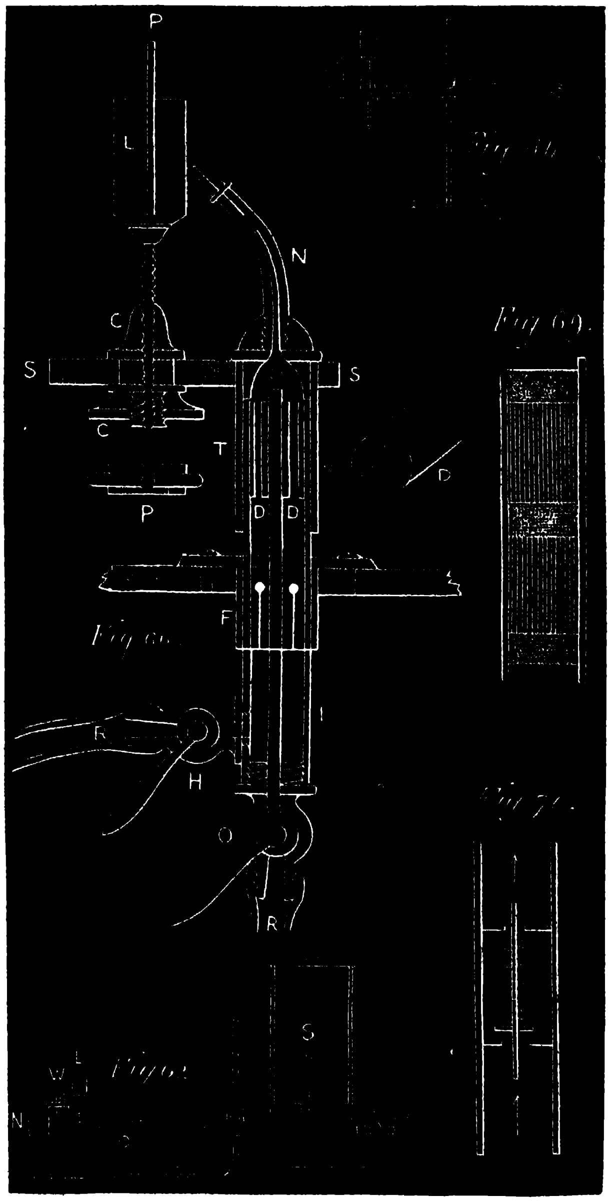


Fig. 63.

Oxy-house Gas Jet.—In this arrangement the spirit is replaced by a house-gas flame supplied by a separate tube, as shown in Fig. 64. If thus disposed, it is better to flatten the end of the tube where the gas is ignited, and better still to make this terminal burner of a piece of tube of larger size; but the jet usually employed is arranged so that the house-gas envelops the oxygen nozzle to secure a more perfect combination of the two gases before they strike upon the lime-cylinder, being in fact a "Herapath's blowpipe" modified for the lime light, as shown in Fig. 65. In both these arrangements it is impossible for either gas to pass from one tube to the other, and form an explosive mixture, which has given rise to their being called "safety blow-through jets." The drawback to this form of jet is that the gases strike upon the lime with a roaring flame; but, on the other hand, house gas is cheaper than spirit, involves no lamp-filling and wick-trimming, and simply requires the tube set apart for the carburetted hydrogen to be connected by a vulcanised rubber tube with any house supply, such as the burner of a chandelier or gas bracket, and the other tube with an oxygen bag, gasometer, gas-holder, or condensed gas-bottle. Though great faith has been established in the minds of amateur lantern-workers as to the exceptional safety of this arrangement of jet, I must say that a form of oxy-house gas jet that is far neater, gives a better light (in consequence of the gases being perfectly mixed before they issue from the blowpipe nozzle), and is free from the objectionable roar referred to, may be used with equal safety, if we consider the improbability of house-gas at the ordinary pressure of the main being driven into an oxygen bag when sufficiently weighted or *vice versa*. The arrangement I refer to is a modification of Professor Daniell's oxy-hydrogen blowpipe, which, in its original form, was showy but cumbrous, being intended for lecture-table experiments, but as arranged for the lantern or for photographic enlargements, it is represented in Fig. 66. The difference between Herapath's and Daniell's jet is, that while the former has an *opened mouth nozzle*, as shown in Fig. 65, in the latter the gases are mixed in small volumes just before they issue from *a nozzle of small bore*. The arrangement is shown in section in Fig. 66. A stout tube, I, is fitted at its lower end with lever stop-cocks for hydrogen and oxygen, H and O. This tube slides through a spring flange, F, screwed to the floor of the lantern, etc., or it may be supported on a separate telescopic adjustable stand. Through the centre of this tube passes a fine pipe connected with the lower stop-cock, O, that conveys the oxygen to its upper end, where it is supported by a metal plug, D, that is drilled with holes to allow the passage of the hydrogen admitted by the stop-cock H. Over the tube, I, a tube, T, closely fits that carries the nozzle N, and lime-stage S S. The lime-cylinder L is supported on the lime-pin P P, that can be adjusted upwards or downwards by means of a coarse screw, working through a clamp nut, C C, that slides to and fro in a slot cut in the arm S S, to allow of the lime being adjusted nearer to or further from the nozzle N. The taps H and O are respectively connected with the house supply, and a bag or other oxygen receptacle by the india-rubber tubes R, R. As in the previous arrangement, the hydrogen is first admitted and ignited at the point of the nozzle, and after it has warmed the lime, it is turned on full or nearly so, and the oxygen is then slowly admitted till the lime is rendered fully incandescent, the best effect being obtained when the house-gas is slightly in excess, as a preponderance of oxygen cools the lime and diminishes the full brilliancy obtainable by the proper mutual adjustment of the two gases. This form of jet may also be used for burning the gases under pressure, and is the arrangement in general use for "theatre lights."



Oxy-Hydrogen Jet.—In the early days of lime-light manipulation, both the gases were mixed in one bag or bladder, in the proportions of one quart of oxygen to two of hydrogen, and were then burnt in connection with a safety-jet. Fig. 67 shows such an arrangement, which has long been used and recommended by Woodward in his work on "Polarised Light." F represents the bladder of mixed gases placed in a descending pressure-frame, G H, the weights being placed on the shelf H below the bladder. This bladder can be replenished from a second E, fitted with transfer taps. The lime-jet, L, is not only fitted with a Gurney's water-chamber, but also a Hemming's wire gauze safety-tube, K, to be hereafter described.

At the present day few persons would care to commence any exhibition or lecture with less than 12 cubic feet of the gases, and each gas in separate bags with 1 cwt. on each bag, so as to be sure of sufficient supply, and a pressure that will ensure the full intensity of light obtainable by the "oxy-hydrogen" or "mixed gas jet;" and few practised manipulators now put faith in safety-jets, but rely entirely on the rules I have previously laid down, as to keeping the gas receptacles equally and always weighted during the time the apparatus is in action, and the gases burning. Nevertheless, it will be well to describe the various contrivances that have been recommended to ensure safety while using the oxy-hydrogen jet.

Gurney's water chamber is simply a small metallic bottle, to the top of which the nozzle and lime are attached. The *mixed* gases pass from their receptacle by a tube that turns downwards, to allow the gases to rise in bubbles through the entire depth of water with which the vessel is two-thirds filled, as shown in Fig. 68. Should the ignited gases by any accident recede, it was supposed that the water would cut off the delivery-tube, and any explosion would be confined to the small portions of gas above the water; but I have heard of a case where the rising bubbles formed a train of explosive gas and passed to the delivery-tube.

Hemming's safety tube (Fig. 69) is formed of an alternate series of horizontal layers of fine meshed wire gauze, and vertical bundles of wires, through which the gases are driven, and it was supposed would retard and extinguish an explosive mixture, if there were any tendency to recede. But hydrogen under pressure can be driven back into a bladder partially filled with oxygen placed under weaker pressure, and that if a light be applied to the free end of the wired tube, on the weight being removed from the bladder, a "suck back," as it is termed, will occur, and an explosion will follow.

Taylor's safety valves are of two kinds: one, a light flap valve hanging by a hinge, which may at once be disposed of, as not being reliable unless *accurately levelled*, or inclined so that the flap should lay upon the aperture that admits the gas. The second is a more practical and reliable form, shown in Fig. 70. This is a spring valve that can be fitted between a pendant portion of the india-rubber delivering-tubes, and allows the flow of gas under pressure to pass in *one direction only*; should a greater pressure be set up in the wrong direction, the spring comes into play, and the valve is tightly closed.

The so-called safety-jets, having valves, bundles of wires intersected by wire gauzes, and even Gurney's water-chamber, are, I believe, snares to careless operators, for if the pressure on the bags be unequal, the gas on which there is the greatest pressure being unable to escape in sufficient quantity from the bore in the nozzle of the jet, gradually forces back the gas under lesser pressure, an explosive mixture is gradually formed in the bag, and if the smaller weight is accidentally or carelessly removed, an explosion must follow.

SILK CULTURE.—III.

By Alexander Wallace, M.D.

TREATMENT OF GROWING WORMS—TABULAR PROGRAMMES OF THE EDUCATION OF EGGS, ETC.

As time progresses and the worms get larger, the temperature should also increase, and the hygrometer show a dryer atmosphere. As much ventilation should be given as possible, avoiding draughts and currents of cold air. Food must also be given in larger quantities, and at more frequent intervals. In the 3rd age five feeds a day will often be necessary, and in the 4th age from six to eight feeds may be given. It will not now be necessary to cut the leaf so fine. In many *magnaneries* the leaf is given whole after the 3rd age; but by using the mulberry leaf-cutter economy of leaf is obtained even to the last, as well as economy of labour. Regularity in the hours of feeding is essential. During the 1st age 7 square feet are required for every ounce of worms; in the 2nd age, 14; in the 3rd age, 34; in the 4th age 82; and in the last age, 183 square feet must be allowed. It follows, therefore, that in calculating how many worms may be educated in a given space, regard must be had to the last age, when the greatest space is required; but, as I have before observed, it is wise to provide a much larger supply of eggs than the number actually to be reared, so as to provide against losses that may ensue during the education. One ounce of eggs will give at a rough computation about 40,000 worms; these should consume from 1,200 to 1,600 lb. weight of leaves, and should produce at least 45 lb. of cocoons. During the education there will be carted away in refuse from the trays 745 lb. 8 oz., of which 155 lb. 8 oz. is excrement, the rest stalks, fruit, and unconsumed food. Hence it appears that the worms would consume about 770 lb. of leaf, which would suffice, if all the worms lived, to produce 120 lb. of cocoons; hence the deduction that 16½ lb. of pure leaf is sufficient to produce 1 lb. of cocoons, provided none of it be wasted.

Subjoined is Count Dandolo's programme of the education of 5 oz. of eggs:—

1814. Days of rearing.	Months.	Sorted leaves.			Internal temp. at 5 a.m.	External temp. (westerly) at 5 a.m.	Hygrometer of M. Bellani.	Weather.
1st age	May.		lb.	oz.	Deg.	Degrees.	Deg.	
Day 1	23		2	2	73-71	53	...	Rain.
„ 2	24		3	9	71	48	...	Rain & storm.
„ 3	25		4	9	71-69	44	...	Rain & sun.
„ 4	26		8	0	69	46	...	Clouds & sun.
„ 5	27		7	9	71	50	...	Clouds.
„ 6	28		4	3	71½	55	...	Rain.
			30	0				
2nd age								
Day 7	29	Small branches and leaves.	8	10	71	48	68	Rain.
„ 8	30		16	8	71	53	70	Fog, sun.
„ 9	31		23	6	68	57	64	Ditto.
„ 10	June 1		22	8	68	57	66	Rain.
„ 11	2		10	8	68	64	66	Rain & sun.
„ 12	3		1	8	69	62	70	Clouds.
			83	0				
3rd age	June		lb.	oz.	Deg.	Degrees.	Deg.	
Day 13	4	Small branches and leaves.	21	0	69	55	68	Rain & sun.
„ 14	5		45	0	68	55	69	Clouds & sun.
„ 15	6		60	0	69	62	70	Rain & sun.
„ 16	7		90	0	69	57	75	Rain.
„ 17	8		75	0	69	56	74	„
„ 18	9		80	0	69	53	79	Rain & sun.
„ 19	10		3	0	69	57	78	„
			324	0				
4th age								
Day 20	11	Small branches and leaves.	75	0	69	57	76	Rain & sun.
„ 21	12		127	8	69	64	75	Clouds & sun.
„ 22	13		180	0	68	65	71	Fine.
„ 23	14		195	0	66	62	74	Clouds & sun.
„ 24	15		249	0	66	65	75	Sun & rain.
„ 25	16		105	0	68	66	72	„
„ 26	17		7	8	69	57	70	Fine.
			939	0				
5th age								
Day 27	18	Small branches and leaves.	180	0	68	60	72	Fine.
„ 28	19		270	0	68	62	73	Rain & sun.
„ 29	20		360	0	68	57	73	„
„ 30	21		465	0	66	59	75	Rain.
„ 31	22		540	0	68	57	73	Clouds & rain.
„ 32	23		675	0	68	53	72	Rain & sun.
„ 33	24		825	0	68	55	74	„
„ 34	25		975	0	68	53	74	„
„ 35	26		750	0	69	55	73	„
„ 36	27		420	0	69	55	73	Clouds & rain.
„ 37	28		270	0	69	50	72	Rain & sun.
			5730	0				

SORTED LEAVES.

5th age	5730 lb.	
4th age	939 „	
3rd age	324 „	
2nd age	83 „	
1st age	30 „	
Total sorted leaves	7106	
Add	1024	refuse leaves, loss from evaporation, etc.
	8130 lb.	

Or 8,630 lb. of leaf picked from the tree to feed 5 oz. of eggs, or 1,026 lb. of leaf for 1 oz. of eggs.

OBSERVATIONS.

First Age.—The silkworms on some tables or hurdles roused sooner than others. By reason of the exterior cold, the temperature of some parts was a degree and a half below other parts, although the whole was well closed, and lined to keep out the cold. This degree of cold was on the side of the apertures and lower rows of tray hurdles.

Second Age.—The silkworms became torpid, and roused with more regularity, and at less distant periods than in the first age.

Third Age.—All proceeded with regularity. There were twenty-four pounds more of mulberry-leaf consumed this year than in the preceding. There was less refuse picked from the leaves this year, consequently the average quantity of leaf must have been nearly the same in both years.

Fourth Age.—Two days were employed in cleaning the wickers, because the silkworms that were placed in the coldest part of the laboratory became torpid, and roused a whole day later than the others. Thirty pounds more of sorted leaves were consumed than in the previous year, but there was less refuse. The progress of the fourth age was tolerably regular.

Fifth Age.—The cold and variableness of the weather under these last shown days of the season were remarkable. The silkworms continue to prosper. But as the nights were very cold, an even temperature throughout every part of the laboratory could never be obtained. Fires were lighted in the stoves, and thick wood was burnt in the grates to maintain the necessary temperature. There were 84 lb. more of leaves consumed than in the previous year. The refuse of the leaves and the weight of dung were less than in the previous year. There were fewer mulberries on the branches, and even these were lighter than in 1813. There were obtained 6 lb. more of cocoons. Some wicker hurdles required a little leaf on 29th of June, the thirty-eighth day of the rearing of the silkworms, and they received that which had not been consumed the preceding day—1,626 lb. of leaves per ounce of eggs. The silkworms of 5 oz. of eggs, having consumed 8,130 lb. of leaves, produced 601 lb. of choice cocoons, and 4 lb. 8 oz. of coarse floss; giving, therefore, about 20 lb. of leaves consumed for 1½ lb. of cocoons.

In order to show what may be done in this country, I annex the table of temperature as observed in my small *magnaneries* at Colchester, in 1871; with a description of the room, and the dates of my education. The hygrometer used was obtained from Negretti and Zambra, called a damp-detector, small, portable, and sufficiently accurate for the purpose. About 25° seemed the medium point at which the worms may be considered in a safe atmosphere. Should the indicator not reach that point, it became necessary, either by means of extra ventilation or dry warmth from gas-stove, to renovate the atmosphere of the *magnanerie*. A good blaze in the Arnott's stove, from straw, wood, or fresh coal, will often accelerate ventilation, and freshen up the room. When there is a deficiency of ventilation, or an excess of moisture in the air, the worms are sluggish, lose their appetite, and rise very slowly. Vigorous, hungry worms, that consume leaf largely, are sure to do well.

Date.	Minimum during night.	Temperature at				Hygrometer.	Remarks.
		9 a.m.	12	3 p.m.	6 p.m.		
June 4	57½°	61°	62°	63°	65°	28°	Worms begin to hatch out.
„ 5	60	64	65	64	64	30-26	
„ 6	63	62	63	65	65	28-25	
„ 7	58	61	63	62	61	27-25	No sun, no gas-stove.
„ 8	60	62	64	65	62	27	Gas-stove at night.
„ 9	62	65	70	68	68	27	Gas-stove during day.
„ 10	66	70	70	70	70	26-25	Ventilators open for first time. No gas-stove.
„ 11	62	66	68	70	66	27	No gas-stove.
„ 12	62	68	75	75	74	27	Gas-stove, no fire.
„ 13	64	70	70	70	70	25	„ „ „
„ 14	70	70	72	74	74	28	„ „ „
„ 15	70	72	73	75	75	30	„ „ „
„ 16	69	72	75	72	70	30	Fire for the first time in Arnott's stove.
„ 17	69	73	71	69	69	30	Dull, muggy weather.
„ 18	67	71	72	72	70	30	„ „ „
„ 19	65	70	73	70	70	29	
„ 20	67	72	70	72	75	29	
„ 21	66	71	77	75	73	28	
„ 22	68	70	74	70	73	25	
„ 23	66	71	72	70	70	26	Cold north wind.
„ 24	65	70	70	69	73	26	Very cold, no sunshine
„ 25	68	67	67	72	70	24	Cold.
„ 26	65	70	71	73	72	24-22	
„ 27	63	70	73	73	75	23-22	Warmer.
„ 28	65	68	73	70	70	25-26	
„ 29	70	73	72	71	71	25	Gas-stove at night.
„ 30	67	70	71	72	71	26	
July 1	64	70	71	71	71	25	
„ 2	65	70	72	70	71	27	Showery.
„ 3	65	70	73	75	73	28	„
„ 4	66	70	66	70	70	28	
„ 5	69	71	72	71	70	26	Thunder.
„ 6	69	71	70	70	70	26	
„ 7	74	72	75	75	75	26	Gas-stove at night.
„ 8	69	73	75	74	71	28	
„ 9	67	72	75	75	72	27-25	First cocoons began.
„ 10	67	70	72	73	70	25-24	
„ 11	66	71	72	70	70	26	
„ 12	64	70	72	73	70	25	
„ 13	72	74	71	73	73	25-26	Gas-stove at night.
„ 14	71	72	76	75	70	27	
„ 15	73	75	75	77	75	27	
„ 16	76	74	75	75	75	26	
„ 17	71	72	76	77	75	26	
„ 18	72	71	75	75	74	25	
„ 19	68	72	75	76	74	25	
„ 20	71	72	71	72	71	25	
„ 21	69	71	73	76	73	24-25-23	
„ 22	69	71	72	74	73	24	
„ 23	66	71	73	74	72	24	
„ 24	66	71	72	73	72	23	
„ 25	66	71	74	74	72	24	
„ 26	66	72	74	74	72	23	
„ 27	68°	71°	73°	76°	76°	22°	
„ 28	68	71	75	75	73	22	Moths emerging.
„ 29	68	71	75	74	72	23	Moths coupling and depositing eggs.
„ 30	67	71	71	72	70	23	
„ 31	63	71	73	74	71	23	
Aug. 1	67	71	73	75	73	22	
„ 2	66	71	75	76	74	21	
„ 3	67	71	75	76	74	21	
„ 4	70	73	73	70	69	22	
„ 5	64	70	72	75	73	21	

I tried three samples of eggs for my experiment:—No. 1, a small sample, about ¼ oz. (yellow), from Japan, brought by a friend, probably "bivoltine;" No. 2, a second sample (¼ oz., from Japan, of a noted (yellow) race, imported; No. 3, 1 oz. of a (yellow) Japanese race, reproduced in 1870 in Europe.

	Hatched out.	First Moult.	Second Moult.	Third Moult.	Fourth Moult.	Spinning.	Life of the worm lasted.
1.	June 6	June 14	June 21	June 28	July 2	July 11	38 days.
2.	„ 5	„ 13	„ 21	July 2	„ 10	„ 20	45 „
3.	„ 4	„ 12	„ 20	„ 28	„ 8	„ 18	44 „

My *magnanerie* is on the ground floor, with no room above it, 10 feet 9 inches high, about 20 feet long, 15 feet broad, containing about 3,100 cubic feet of space. M. Taurigna, in his manual, states that about 2,100 cubic feet are required for each ounce of eggs. "Une magnanerie ou chambre destinée à une éducation de cinq onces doit avoir au moins 72 mètres* de surface, c'est à dire, 12 mètres de longueur, et 6 de largeur; sa hauteur doit être au moins do 4 mètres, ce qui produits un vide de 288 mètres cubes, soit 57 mètres cubes par once de 31 grammes" (our English ounce).

The only window in the *magnanerie* faces west; a skylight facing north lights the east end of the room: there are three doors, on the eastern, western, and southern sides respectively. The southern wall is scarcely at all exposed to the sun; but the roof, facing south and north, is scarcely if ever shaded; on the southern side is a small room, and outside that a greenhouse, so that a constant current of air on sunny days, warmed by the glass house, permeates the *magnanerie*. For ventilation, there are three openings in the ceiling, about 12 inches square, into the space under roof, closed with perforated zinc; a ventilating brick is over the west window, and two other openings cut in the north wall just beneath the level of the ceiling. These, as also the perforated brick opening, are closed at will by wooden shutters; the skylight is also made to open. But the most important ventilating apparatus is an Arnott's stove, with the addition of an opening made just below the ceiling into the chimney, fitted with an Arnott's ventilator, which may be closed at will. This aperture opens into an iron pipe 4 feet long, running upwards inside the chimney, and with a cap on the top to prevent the downfall of soot. The warmth from the fire below creates in this 4 feet pipe a constant upward draught of air, which must be supplied from the room; thus the upper strata of air are continually drawn off. The Arnott's stove below is set in fire-brick, and constructed with a coal-box beneath, which supplied fuel for nine hours without requiring further attention. The floor of the coal-box was elevated from below by a lever and ratchet apparatus, and thus coal was lifted up from below as required for further use. This box was filled every night at six p.m., and the fire relaid and lighted. Being made up again at ten, it kept alight all night. In the morning, however dull and black the mass appeared, by means of elevating the coal below and drawing the blower down in front, a brisk blaze was soon induced, and in half an hour a very hot fire; the fire-brick when once hot remained so for at least twenty-four hours. Hence there was maintained throughout the twenty-four hours, and especially at night, perpetual ventilation, not merely as regards the lower strata of air, but also, by means of the pipe in the chimney, the upper strata were gently and imperceptibly drawn off; at the same time great heat was given off by the fire-brick, and thus a most efficient apparatus was brought into action to counteract the atmospheric difficulties of our English climate, and with perfect success, as evidenced by the records of the temperatures in 1871. Another warming apparatus at the farthest end of the room was occasionally used—a Mussett's gas-boiler and horizontal coil of four pipes 3 feet long, was placed at the southern side of the room; two atmospheric burners heated the boiler, and the gas fumes were carried off by means of a close-fitting iron case and pipe, carried over and across the room to the chimney. Half an hour after the gas was lighted the water in the pipes became so hot that the hand could not be retained on them; the gas was then lowered, and the water kept about boiling temperature. In this way, at an economical rate, extra heat was occasionally supplied, especially at night and during the cold sunless days, and on some occasions when the Arnott's stove was not in use. By means of this apparatus the temperatures were kept very equable, and ventilation thoroughly attended to. It will be noted that, notwithstanding the cold and wet season, especially during the month of June, the temperatures were kept at an equable and moderate rate, and the hydrometer at a fair level, and this in one of the coldest and most inclement seasons we have experienced. After the experience of the year, the climate of England need not be cited as offering any difficulties to the maintaining in our *magnaneries* the necessary atmospheric and hygrometric conditions for the culture of the mulberry silkworm.

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* A mètre is equal to 40 inches as nearly as possible.

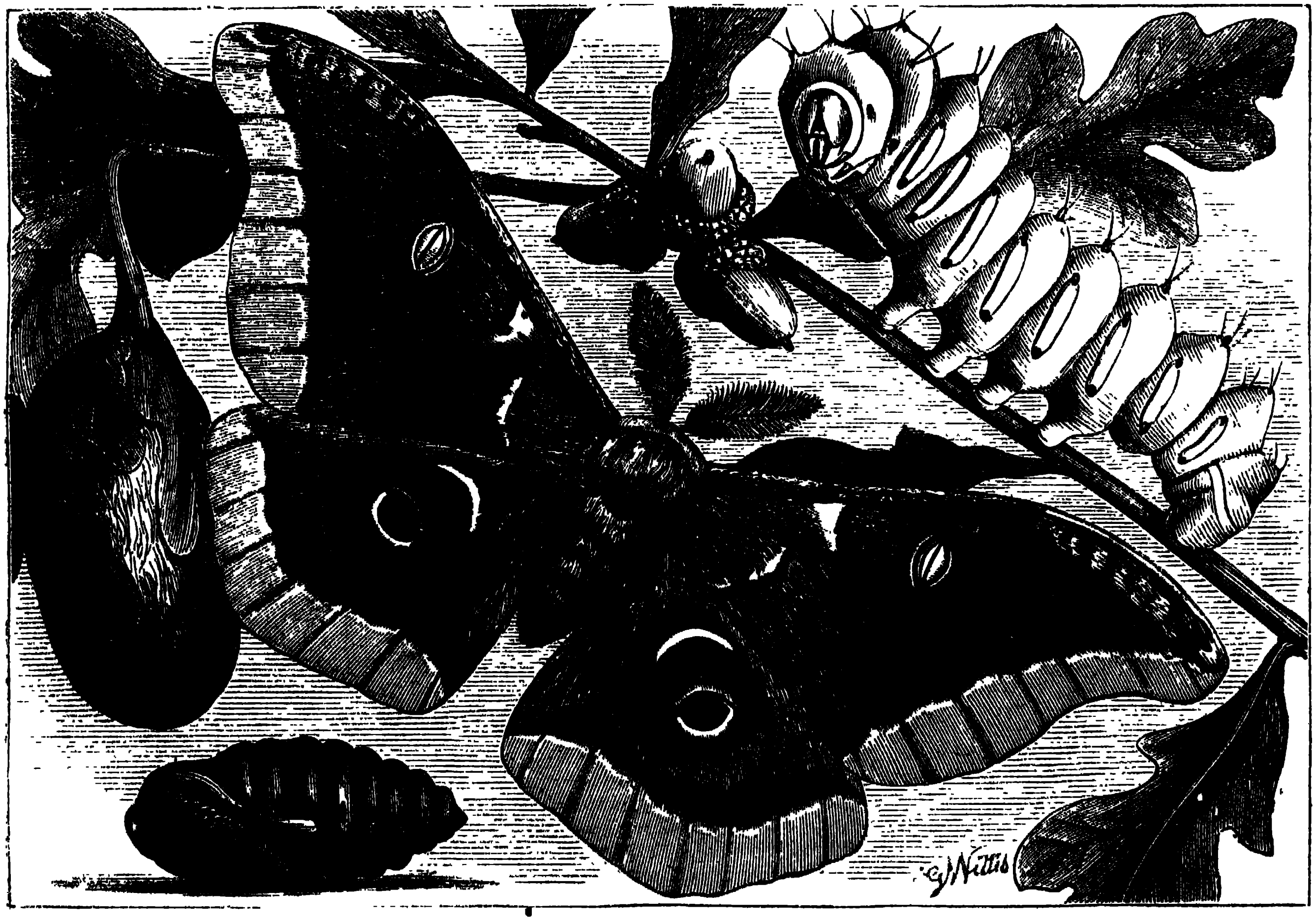
Fig. 4.—CATERPILLAR, COCOON, CHRYSALIS AND MOTH OF THE BOMBYX POLYPHEMUS.

As the worms get larger, their refuse gets heavier and more bulky, and it is well to change them oftener, at least twice a week, and in the last age every day if possible. I prefer to use nets for the first four ages, but for the last age the *papier filets*, chiefly because nets will not sustain the great weight of worms at that age when lifted off in cleaning the trays without stretching very much, and this disarranges the worms. During the first three ages, in cleaning, nets may be put over the trays, and removed by one person by the aid of two sticks with a nail at the end, one in each hand; the nail being inserted in a mesh at one corner of the net is twisted round, this retains the farther corner; the nearer corner of the net is held in the same hand as the stick. Thus one side of the net is held tight by means of the stick in each hand, and is thus easily lifted off and replaced; but in the last two ages it becomes desirable to have extra help in changing the nets, and the *papier filets* are more easily handled. It is at this point that the table in the centre of the room becomes of considerable use. The operation of cleaning is as follows:—A fresh *papier filet* having been placed on a tray early in the morning, is fed over; at noon, the whole (including the brown paper below) is removed in one operation and placed on the floor alongside the table, whereon another sheet of brown paper has been placed ready. The upper *papier filet* is now removed with the worms, and placed on the table, and thence returned with the sheet of brown paper to the tray; the old bed is then placed on the table, looked over and cleaned, the refuse being thrown away, and the *papier filet* hung out to air till the next day, when it is used again. In this way tray after tray is cleaned rapidly and easily; and since it takes less time to adjust a *papier* over the tray, owing to its stiffness, than a net, it cannot be denied that the *papier filets* have an advantage over the nets in the late stages. As spinning-time approaches, their excretions become moister and enormous in quantity, and there is therefore greater exhalation from the worms and from their bed; they eat enormously. Great cleanliness and abundant ventilation are therefore necessary. At last they become of a yellowish translucent colour, their heads seem very small, they stop feeding, and as their intestinal canal empties so the lower segments of the body contract, and the ultimate segments get narrower and tail-like. They wander about, approach the edge of the tray, and hold up their heads as if looking for something. Then is the time to set up the bushes for the cocoon to be spun in, and the labour of the last moult is now to be critically tested.

CIVIL ENGINEERING.—XIV.

BY R. G. BARTHOLOMEW, C.E., M.S.E.

BREAKWATERS.

THE harbour at Aberdeen as left by Smeaton was capable of still further improvement by a judicious extension of breakwaters and piers. In 1810 Telford was employed to carry out the object. He found the south or catch-pier, which Smeaton had erected, destroyed, and as this was an essential structure, Telford constructed another of a more substantial character, of cut granite, having a talus or slope seawards of 1 in 5. This was followed by an extension of the north pier to a distance of 300 feet in advance of the point Smeaton had carried it to, and this was found so beneficial to the harbour, that it was subsequently extended 565 feet further. The extremity of this immense projection, stretching out upwards of 2,000 feet in a north-easterly direction into the German Ocean, has a slope of 5 to 1, and stands the fury of the prevailing winds well. The mode of constructing this breakwater was original and very successful. The bottom is a loose sand and gravel, and in order to consolidate the work under low water, large stones were dropped from lighters, the interstices being filled in with smaller, until it was brought near the level of low water, at which level the ashlar work commenced. This ashlar work is not laid as usual, horizontally, but at an angle of 45°, inclining backwards, by which arrangement it was better able to withstand the action of the sea during the progress of the work.

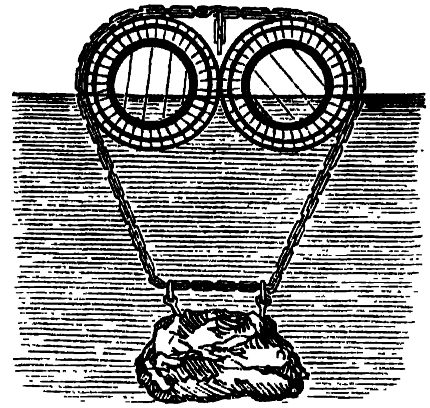

Fig. 33.

Fig. 32 shows a longitudinal section of the pier, and the position of the ashlar stones.

The stones employed in the foundation are of a gneiss formation, and being difficult to dress, the local masons call them "heathens." Some of these weighed from five to thirty tons, and were slung between the bows of two lighters having counter-weights at the stern; by this means they were floated to the pier-head, and deposited in their proper position. A railway was laid down along the pier, with a double-headed crane at the end moving on a framing of timber resting on rollers. This railway advanced with the work, and greatly facilitated its progress.

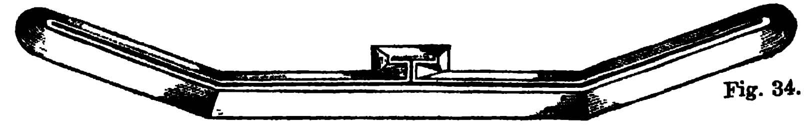

Fig. 34.

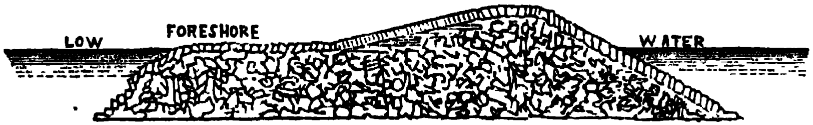

Fig. 35.

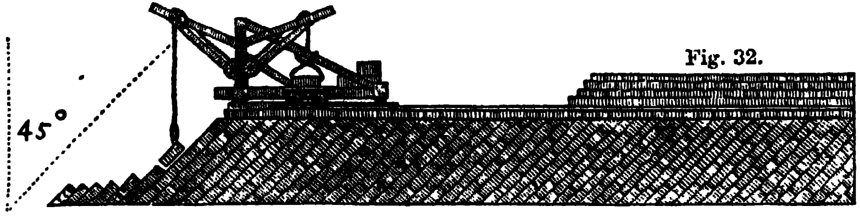

Fig. 32.

There are many towns upon the east coast of Scotland which from their exposed position require to be protected by piers. These piers, from the character they sustain, and the object with which they are erected, partake essentially of the nature of breakwaters. Peterhead possesses an important breakwater of this kind. The granite in the neighbourhood, called locally "Pacey whin," is an admirable material for these structures. It is excessively hard, and cannot be worked in the ordinary manner, but the masons who use it are aware of a peculiarity it possesses, and avail themselves of it. The stone has a natural cleavage, or "greet" as it is termed, the position of which those accustomed to it readily ascertain, seldom mistaking it. They then draw a line in the direction of the "greet," and sink a row of holes along it with a heavy double-ended blunt-pointed hammer, the points being highly tempered. These holes are then united by a groove into which they place steel wedges, striking the wedges in succession with a heavy hammer along the whole line, till the stone splits asunder, the fissure being nearly as straight as a saw-cut, but not so smooth.

An excellent breakwater pier exists at Frazerburgh, on the east coast of Scotland. It has three bends; the first runs north-east for 272 feet; the second turns a little to the south of east for 440 feet, and from thence returns almost due south for 100 feet. This pier is 33 feet 7 inches thick at the top, not reckoning the parapet wall, which is 4·5 feet thick in addition. It stands 20·5 feet above low-water mark, and slopes considerably on the sea face. Towards the harbour the face is curved.

In the construction of the piers at Pulteney Town, in Caithness, Telford made use of casks made of fir, in order to float the stones employed in constructing the foundations. Some of the stones are of immense size and weight, varying in length from 3 to 20 feet, and from 8 to 15 inches in thickness, their breadth being about 3 feet 8 inches. The casks weighed about 25 cwt. each, and displaced about 445 cubic feet of water, so that two of these casks would support 34½ tons of stone. Four casks were made use of, and they were sometimes employed to assist in floating the vessels laden with stone. Owing to the limited depth of water in the harbour, the stone-laden vessels would not always float in it, not even at ordinary high tide; four of these casks placed two on each side of the vessel, and connected with chains passing under the keel, exercised a lift sufficient to enable them to enter and deposit their burden. The casks did not cost more than £8 each, and by their aid the stones, which had to be brought three miles, cost only 1s. 6d. per ton when deposited. Some of the stones employed were brought from positions under low-water mark. Holes were then bored in the upper face of the stone, and an iron shank, 2 inches in diameter at the bottom, and tapering upwards to 1¼ inch at the top, was inserted and a wedge driven in. The top of the shank was furnished with a ring, to which was attached the chain connected with the cask, the chain being tight at low water; at the flow of the tide, the stone was floated and brought to its destination. The casks employed were strutted inside similarly to the spokes of a wheel, and strongly hooped round on the outside. The casks were employed in pairs in floating the stones, and two of the shanks we have described, which partook of the character of a *lewis*, were inserted in each stone; by this ingenious disposition of the floating power, the stone was prevented from swerving. This arrangement is shown in Fig. 33.

A very fine pier of modern construction exists at Holyhead, and protects the harbour from the north and west gales. The northern pier is upwards of 1,300 yards long, and 270 feet broad at the base; the slope towards the sea is 5 to 1; the breadth at the top is 8 feet. The end of the pier stands 47 feet above low-water mark, and widens to 164 feet. All the masonry is constructed of granite found in the neighbourhood.

In many parts of the coast, the sand lies very compact and firm when not subjected to the action of the sea. A durable and inexpensive plan of raising a breakwater or pier upon this kind of bottom is to drop a large quantity of rough stones so as to form an artificial rock or base for the superstructure, in the proper direction, and of ample width, upon the sand. These stones sink by degrees into the soil, and others following upon their top will eventually cause the whole mass to find a solid bearing upon the sub-stratum. Of course more material is employed than would be the case if the pier were erected upon a regular base; but as the stones are undressed, and no timber employed, the cost is less than if piles were made use of.

Plymouth Breakwater is one of the finest works of marine engineering upon our coasts. The Sound is a fine sheet of water more than three miles wide, and possessing an area of about 4,000 acres, with a depth of water equal in some parts to 60 feet at low spring-tides. Nothing was wanting, in fact, to render this space of water the finest harbour possible, except the position of the entrance, which is almost due south, and lay exposed to the fury of the south and south-west winds. To obviate this only defect, after many plans were discussed and rejected, it was resolved to carry out the plan proposed by Rennie, and in 1811 the necessary authority was issued by the Government to commence the works. Mr. Rennie's proposition was to form a breakwater across the middle channel by depositing a quantity of large blocks of rubble into the sea; the blocks being from two to twelve tons each, were to be allowed to find their own base, and in this manner the sub-structure was to be raised. He proposed that the breakwater should be 5,100 feet long, the central portion, 3,000 feet long, standing due east and west, with a wing at each end 1,050 feet long, inclined inwards at an angle of 160°. This was the plan which was carried out. Fig. 34 represents a plan of the breakwater.

The stone employed is principally limestone taken out of quarries which were purchased from the Duke of Bedford at Oreston. Considerable difficulty was experienced in finding contractors willing to undertake the work, owing to its novelty, except at prices so high that it was determined to contract only for a portion of the work at a time. The price paid for taking and depositing the first portion of the rubble was 2s. 9d. per ton, but afterwards, when the contractors became more accustomed to the work, this was reduced to 1s. per ton. The manner in which the stone was transported from the quarries to the breakwater was as follows:—Vessels of about 60 tons burden were employed having two lines of rails laid along them, parallel to each other, the ends near the stern being raised on an inclined plane to prevent the trucks from running too far. The blocks of stone were placed upon trucks which were then run upon the parallel lines of rail. After the vessel arrived at its destination, the trucks were discharged by tilting them up by means of windlasses fixed to the deck. The stone was deposited direct into the sea from the trucks. Steam-tugs were employed to tow the vessels in order to economise time. At every thirty feet along the intended line of the breakwater, buoys were laid down, to which the laden vessels were attached whilst discharging their cargo. A careful account of the quantity deposited, and the level to which it rose, was kept, so that the actual state of the work was known at all times.

The process of depositing the rubble proceeded almost uninterruptedly for two years, when portions of the work began to be visible at low water, and very shortly after, a continuous line of about 720 yards appeared. The good effects of this ridge soon began to be manifest, and long before the breakwater assumed its ultimate dimensions it was found of the greatest service in sheltering vessels from the south-westerly gales. The Emperor Napoleon I., who entered the harbour on board the *Bellerophon* during the progress of the work, was greatly struck with its utility.

The stone was raised in large blocks, many weighing fully ten tons, and in depositing them care was taken that the greater number were deposited upon the outer slope. After the larger stones had been lowered to form a base, a smaller class of stones, rubbish from the quarry, and lime screenings were thrown in. These effectually filled up the cavities and interstices, and the whole finding their position by the action of the sea, the mass as it advanced became wedged together. The outer slope, which is about 5 to 1 vertical, was formed by the sea during a storm in 1824. Previous to this storm only the lower portion was laid down with this slope, the upper part, contrary to the engineer's wishes, having been carried up with a talus of 3 to 1 vertical. The effect of the storm, however, fully proved the correctness of Mr. Rennie's views, and consequently the seaward slope remains at 5 to 1 to the present day.

As soon as sufficient time had elapsed to enable the lower portion of the work to become consolidated, the seaward slope down to the foreshore was cased with regular courses of masonry, and by the aid of the diving-bell these courses were dowelled, joggled, dovetailed, and cramped together. The three lower courses were all granite, laid horizontally, dovetailed, lewised, and bolted together. The mortar employed consisted of one part of pozzuolana, and one of Aberthaw lime, mixed with two parts of fine sharp fresh-water sand, the whole being well worked together in a mill, with as little water as possible. This anhydrous mortar set very quickly when used. Roman cement was employed for the outer joints, and for some distance within.

Towards the end of 1815, 615,000 tons of stone had been deposited, sufficient to raise 1,100 yards of the work above low spring-tides. Mr. Rennie's first intention was to raise the breakwater 10 feet above this point, but when the practical utility of the work became so evident, it was resolved to raise the whole structure 10 feet higher. The finishing of the work between the lines of high and low water required extreme care, and involved more expensive work, as it is known that the waves exercise their greatest force between these parallels. The work, however, proceeded with great speed, on some days as much as 1,000 tons and upwards being deposited; and by the end of 1816, 300 yards of the western portion of the breakwater had been raised to the full height of two feet above high water. The work was only fully completed in 1841. The slopes are paved with blocks of the largest stone, firmly united.

It is computed that 3,369,261 tons of stone were used in the construction of the breakwater from 1812 to March, 1841, the cost of the whole work being nearly £1,500,000. Upon a comparison between the quantity of stone deposited and the cubical contents of the entire mass, it is found that, owing to the employment of large blocks of stone, the unfilled interstices occupy about 37 per cent. of the whole. The dimensions of the section, shown in Fig. 35, are as follow:—The exterior slope, below the line of low water, is from 3 to 4 feet horizontal to 1 perpendicular; and from the low-water line upwards, it is 5 to 1. The inner slope is 2 horizontal to 1 vertical, from the base to the top, which stands 2 feet above high-water spring-tides. The width of this portion is 45 feet, the centre forming a ridge 1 foot higher. Beyond the slope towards the sea is an additional foreshore, varying in width from 30 feet at the east end of the breakwater, to 50 feet in the centre, and 70 feet at the west end. This foreshore rises about 5 feet above the level of low water, and serves to break the violence of the waves before they arrive at the principal work beyond.

The western end of the breakwater enlarges into a head 390 feet diameter at low-water level, and diminishes to 75 feet at the top. Upon this head is fixed a lighthouse 14 feet diameter, built of granite, and divided into floors. The centre of the light is 55 feet above the top of the breakwater. The lantern is 12 feet diameter, and 7 feet 6 inches high, and is furnished with a fixed dioptric light with mirrors. The lower courses of the column are secured with slate dowels, placed both vertically and horizontally. The ends of the stone are also dovetailed, and secured in their places by plugs of copper, and by wedges driven into the lower stone.

One of the earliest examples in this country of a breakwater formed of *pierre perdu*, as it is termed by the French—that is, of stones deposited in uneven masses—is to be seen at Lyme Regis upon the Dorsetshire coast. The stones forming this breakwater are so rough and large, and the interstices between them so considerable, that the water flows freely in and out; the violence of the surge is, however, effectually reduced; and it has the advantage, shared by the arched or open breakwaters of the ancients, of affording a certain amount of water-way, and thus reducing its resistance.

We shall now direct attention to a fine specimen of marine engineering—Portland breakwater—than which this country does not possess a more useful work of the kind. It differs from Plymouth breakwater in not being an isolated structure, being connected at one extremity with the land.

So long ago as 1794 the natural conformation of Portland Bay, and the evident facility with which this natural harbour might be rendered safe and accessible in all winds by a judiciously-placed breakwater, attracted local attention, the idea having first suggested itself to Mr. Harvey, the postmaster of Weymouth. In 1812 Alexander Lamb prepared a plan and estimate for a double breakwater—one behind the other—which should cost £400,000. Its length was to be one and a-half miles, or about the same as that now actually constructed, but its position was proposed to be further to the south. The subject was again renewed in 1836, when Rennie was consulted upon the matter. Still it remained in abeyance until 1844, when a Royal Commission, which was appointed to investigate the general question as to the advisability of establishing harbours of refuge upon the eastern and southern coasts of the kingdom, recommended Portland Roads as a suitable locality for a low-water harbour of refuge upon a large scale.

The position of these roads is singular. Bounded upon the south by the high land of Portland Island or Bill, it is most effectually protected from all winds from the south, and for several points to the east of south; whilst that very remarkable natural formation, the Chesil Bank, completely encloses it on the West. The Chesil Bank is an accumulation of shingle and boulders thrown up by the action of the tide and the heavy seas brought in with a south-west wind, and extends for many miles along the Dorset coast to the west of Weymouth; at the latter point it curves to the south, terminating in Portland Bill, which is by its means connected with the main land. It is frequently altered in shape and character by the action of storms, and varies in width; but as a natural buttress it withstands all the violence of wind and sea, and renders the capacious basin upon its eastern side almost landlocked, the only exposed point being from nearly due east, an exposure which the object of the proposed breakwater was to obviate.

The plan proposed was to construct a breakwater extending in a north-east direction for 1¼ miles, commencing at a point near the north-east corner of the island. At the distance of a quarter of a mile from the shore, where the water averaged 42 feet in depth, there was to be an opening 50 yards across, to facilitate the ingress and egress of shipping. The area so protected would equal 1,200 acres, and the cost of the work was estimated at £500,000. This plan, with other modifications which need not be specified here, was eventually carried out.

The work may be said to have commenced by the depositing of the first stone by H.R.H. Prince Albert on the 25th of July, 1849; the quarries had, however, been previously opened out, and the necessary workshops, offices, and machines erected and prepared. The breakwater, as it now stands, extends due east from its starting-point for 1,800 feet in a continuous line of masonry. At this point there is a break or opening of a width of 400 feet. The stonework then continues in the same direction for 302 feet further, and then curves to the north for 1,200 feet, running towards Red Cliff Point for about 4,000 feet, where it terminates in a head standing in about 60 feet of water at low spring-tides. The total length is rather more than 1½ miles, and the space which intervenes between the Breakwater Head and the pier at Weymouth, which is the nearest land on the north side, is about 1¾ miles.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

IV.—INTERNATIONAL MUSEUMS: CLASSIFICATION OF EXHIBITS.

SECTION I.

Class I.—Native Products.

1. *Mineral products.* Metallic, non-metallic, gems uncut or *in situ*, mineral oils, wax, etc.; granites, sandstones, limestones, marble, alabaster, etc.
2. *Vegetable products.* Woods, roots, fruits, grain, hops, bark, hemp, flax, cotton bearers, oil, resin, perfume, colour producers, etc.
3. *Animal products.* Skin, hair, horn, fur, wool, feathers, silk, wax, oil, fat, flesh, perfume, colour producers, etc.

(Representing the economic natural history of countries.)

Class II.—Implements employed for Obtaining Crude Products.

1. *In mining, quarrying, etc.*
2. *In agricultural operations, etc.*
3. *In fishing, shooting, hunting, trapping, etc.*

Class III.—Apparatus and Processes employed for the Extraction and Preparation of Substances, etc., used in Manufactures.

1. *From mineral sources.* Metallurgy, chemical salts, colouring matters, mineral oils, paraffine wax, ozokerit, etc.
2. *From vegetable sources.* Potash, soda, and other chemical salts; colouring matters, perfumes, oils, tallow, flax, hemp, cotton, silk, etc.; gums, balsams, resins, etc.
3. *From animal sources.* Chemical products, perfumes, colouring matters, fats, oil, wax, silk, feathers, wool, fur, hair, leather dressing, ivory, bone, horn.

Class IV.—Substances used for Food.

1. *Mineral produce.* Mineral and aërated waters, etc.
2. *Vegetable and agricultural produce.* Flour, starch, sugar, tea, coffee, chocolate, beer, wines, spirits, tobacco, spices, pickles; preserved vegetables, fruits, sauces, essences, etc.
3. *Animal produce.* Salted, preserved, and potted meats, fish, lobsters, oysters, etc., essences.

SECTION II.

Class V.—Mineral Manufactures for Buildings and Decorations.

Stone cutting, masonry, tombstones, etc.; mantelpieces, alabaster decorations; vases, etc., in various mineral substances.

Class VI.—Glass Manufactures.

Window glass, plain and stained, glass for household use and fancy purposes.

Class VII.—Ceramic Manufactures.

Porcelain, china, earthenware, bricks, cement, etc., for building, domestic, chemical, manufacturing, agricultural purposes.

Class VIII.—Hardware Manufactures.

In tin, lead, zinc, pewter, brass, copper, iron, and steel.

Class IX.—Steel, Cutlery and Edge Tools.

Class X.—Jewellery.

Works in precious metals and stones, and their imitations.

Class XI.—Manufactures in Flax and Hemp.

Class XII.—Manufactures in Cotton.

Class XIII.—Manufactures in Silk and Velvet.

Class XIV.—Manufactures in Wool, Worsted, and Mixed Fabrics.

Class XV.—Manufactures in Carpets and Floorcloth.

Class XVI.—Printed and Dyed Fabrics.

Woven, spun, felted or laid.

Class XVII.—Lace, Embroidery, Tapestry.

Class XVIII.—Manufactures in Hair and Leather.

1. Hair cloth, hair felt, hair plumes, hair seating; human hair, wig, etc., makers; workers in hair devices.
2. Leather ornaments, buttons, cases, purses, fancy goods, hose buckets.
3. Leather stainers, dyers, embossers, gilders, enamellers, japanners, polishers.

Class XIX.—Articles of Clothing.

Hats, caps, bonnets, head-dresses, plumes, dresses, cloths, shawls, plaids, gloves, hosiery, boots, shoes, etc.; in all materials including hair, feathers, fur, skins, etc.; for men, women, and children.

Class XX.—Furniture and Upholstery.

Furniture, upholstery, paper hangings, papier maché, and general decorations, dressing-cases and toilet articles, trunks and travelling apparatus, coffins, etc.

Class XXI.—Paper, Stationery, Printing, and Bookbinding.

1. Paper, card, mill-boards, envelopes, fancy stationery, ink, pens, pencils, sealing-wax, and wafers.
2. Samples of type-founding, wood type-cutting, electrotyping, stereotyping, etc.
3. Letter-press, copper, steel, zinc plate, lithographic, photographic, carbon, graphotype, anastatic, music, and numerical printing.
4. Bookbinding.

Class XXII.—Educational Appliances.

1. *Buildings, fittings, furniture, appliances.* Plans, models of buildings and rooms, galleries, desks, and ink wells,

seats, lockers, teacher's tables, store-closets, black-boards, and supports, easels, cases, etc., for maps, diagrams, educational magic lanterns, school clocks, etc., for infant, primary, secondary, Sunday, adult, middle class, commercial, classical, industrial, trade, technical, medical, and art schools; lecture-rooms, museums, libraries, institutes, colleges, universities; swimming, riding, fencing, and gymnastic schools.

2. *Sanitary appliances.* For schools, colleges, and institutes; for heating, lighting, and ventilating, urinals, closets, lavatories, dormitories; for hats, cloaks, etc.; play, exercise, and drill grounds.
3. *Works and statistics on the theory and practice of teaching in all departments of education.* Roll-books, registers of attendance, progress, payments, tabular forms for collections, school statistics. Intended for the use of masters only.
4. *Apparatus for teaching in infant and children's schools.* Appliances for kinder-garten, for educating eye or hand. Dolls, doll's clothing, etc., models of articles of domestic use, furniture, ordinary workman's tools, and other object lessons; models of animals; diagrams of useful plants, and of those to be avoided as poisonous; ethnological groups, boxes of letters, numbers, abacus frames, dissected maps and globes, picture-books, instructive toys and games.
5. *Reading, writing, arithmetic, mensuration.* Books, tabular lessons, copies, diagrams, measuring instruments, etc., in graduated series, to suit classes.
6. *Geography.* Books, charts, maps, globes, models, diagrams, magic lantern slides, national surveys, etc., in graduated series, to illustrate physical, political, ancient and modern geography, natural phenomena, views of important places, their inhabitants, produce, manufactures, exports and imports, etc.
7. *History.* Books, chronological charts, diagrams, magic lantern slides, models, etc., to illustrate ancient and modern history, historical events, buildings, decorations, manners and customs, modes of warfare, etc., in chronological order, and in relation to the political geographical divisions of the globe, in graduated series.
8. *Religious instruction.* Books, catechisms, charts, maps, models, pictures, magic lantern slides, to illustrate Biblical geography, history, natural history, manners and customs of Eastern life; life, teaching, miracles, etc., of Jesus Christ; creeds of different sects, etc.
9. *Language.* Dictionaries, grammars, and works on the composition and analysis of sentences, philosophy and structure of language; courses of reading and instruction, etc., in ancient and modern languages; tabular lessons in parsing, etymology, and logical analysis, in graduated series.
10. *Mathematics.* Treatises and exercises on pure and applied mathematics, geometrical diagrams; models and drawings for elementary lessons on form and quantity, etc.; simple and cheap mathematical instruments; mariner's compasses, sextants, theodolites, levelling instruments, etc., for school use.
11. *Science.* Books, classifications, diagrams, magic lantern slides, apparatus, instruments, models, specimens, collections of typical forms and species, etc., to illustrate school courses on astronomy, meteorology, mechanics, physics, chemistry, mineralogy, crystallography, botany, zoology, osteology, anatomy, physiology, microscopy, geology; distribution of plants and animals in time and space; collecting appliances for field classes, cabinets, show-cases, etc., in graduated series, for schools, colleges, institutes, etc.
12. *Music.* Books, composition, exercises, diagrams, tabular lessons, cheap musical instruments and appliances for teaching the theory and practice of vocal and instrumental music.
13. *Art.* Books, materials, copies, diagrams; magic lantern slides of the works of the great masters, ancient and modern; models, casts, and appliances for teaching the theory and practice of drawing, colouring, painting, modelling, carving, sculpture.
14. *Domestic and social economy, etc.* Books, diagrams, magic lantern slides, models, etc., for illustrating instruction—

    To males and females: On the laws of health, and the rudiments of domestic medicine, surgery, and nursing.

    To females: On the selection of clothing, food, cooking utensils, and operations; furniture, management of household, servants, children, etc.

    To males: On labour, wages, capital, the conditions of industrial success; moneys, weights, measures of the principal countries of the world, bookkeeping, paper money, bills, interest, discount, banking, investments, annuities, assurance, insurance; commercial and financial terms, rudiments of commercial and domestic law on agreements, leases, rents, bankruptcy, settlements, wills, methods of proceeding in inferior and superior courts, juries; instruction in the rudiments of industrial work, carpentry, turning, gardening, farming, management of pigs, poultry, horses, etc.
15. *Physical education.* Gymnastic apparatus, for indoor use and playgrounds; books and appliances for drill, general, military, naval, for boys, girls, and adults; and military and naval exercises, as single-stick, fencing, rifle-practice, riding, swimming.

    Implements for chess, backgammon, archery, skating, cricket, foot-ball, croquet, skittles, bowls.

    Rocking-horses, hoops, tops, marbles, and other toys.
16. *Appliances for educating the deaf, dumb, and blind.*
17. *Results of teaching.* Specimens of writing, plain and coloured drawings from maps, copies, models, nature, memory, modelling in clay, wax, etc.; needlework, plain and artistic; industrial work generally.
18. *Professional and special education.* Books, specimens, diagrams, magic lantern slides, instruments, apparatus, etc., employed in instructing mining, agricultural, chemical, pharmaceutical, medical, engineering, technical, military, naval, legal, clerical, and art students, at professional schools and colleges.
19. *Libraries.* Catalogues and specimens of collections of books, etc., classified for the libraries of schools, colleges, local institutions, and societies; lending and travelling libraries, etc.

CLASS XXIII.—PHILOSOPHICAL INSTRUMENTS.

Mathematical drawing instruments, rules, scales, verniers, goniometers, dividing and gauging instruments, calculating machines, weighing instruments, balances, hydrometers, etc.; pyrometers, pressure and vacuum gauges, air pumps; barometers, thermometers, and other meteorological instruments; surveying instruments, rainmeters, sextants, acoustic apparatus, optical glass, prisms, lenses, mirrors, spectacles, ophthalmoscopes, heliostats, artificial sources of light, photometers, lighthouse apparatus, magic lanterns, dissolving view apparatus and slides, optical demonstrating appliances, spectroscopes, chromatic, diffraction, polarising apparatus, etc.; photographic apparatus, etc., stereoscopes, race and opera glasses, terrestrial, nautical, and astronomical telescopes, microscopes, thermotic, thermo-electric, electric, voltaic, electro-magnetic, magneto-electric, magnetic apparatus, chemical apparatus, etc.

CLASS XXIV.—MEDICAL APPLIANCES.

1. *Surgical instruments and appliances.*
2. *Pharmaceutical preparations.*

CLASS XXV.—APPARATUS FOR SAVING LIFE AND PROPERTY.

Ambulances, etc.; sanitary appliances; life-boats, rafts, fire-extinguishers, fire-escapes, fire-engines, salvage appliances, life and fire office statistics, etc.

CLASS XXVI.—HOROLOGICAL INSTRUMENTS.

Watches, clocks, astronomical clocks, etc., and trades connected therewith.

CLASS XXVII.—MUSICAL INSTRUMENTS.

Accordions, concertinas, bag-pipes, seraphines, harmoniums, organs, tambourines, drums, harmonicons, trumpets, horns, bugles, flageolets, flutes, oboes, guitars, harps, violins, violoncellos, pianofortes, cymbals, musical bells, triangles, military musical instruments, musical boxes, and other self-acting musical instruments.

CLASS XXVIII.—CIVIL ENGINEERING, ARCHITECTURE, AND BUILDING APPLIANCES.

CLASS XXIX.—MILITARY ENGINEERING, ARMS, AND ACCOUTREMENTS.

1. *Tents, camp equipages.*
2. *Clothing and accoutrements*, with representations of the costumes, etc., of all arms of the army service.
3. *Armour, arms, ordnance, etc.*

CLASS XXX.—NAVAL ARCHITECTURE AND APPLIANCES.

1. *Ships of war, tackle, rigging.*
2. *Arms, ordnance, etc.*
3. *Clothing and accoutrements*, with representations of the costumes, etc., of all arms of the naval service.
4. *Ships of commerce, barges, boats, rigging, tackle, etc.*
5. *Steam-ships, boilers, engines, etc.*

CLASS XXXI.—LOCOMOTIVE APPLIANCES.

1. *By air.* Balloons, etc.
2. *By road.* Coaches, carriages of all kinds, harness, saddlery, and stable appliances, velocipedes.
3. *Railway and tramway appliances.* Railway plant, locomotive engines, carriages, method of signalling, etc.

CLASS XXXII.—MACHINERY AND TOOLS.

1. *Employed in the manufacture of mineral and metallic wares and goods.*
2. *Employed in spinning, weaving, etc., the manufacture of wood, etc.*
3. *Employed in the manufacture of ivory, horn, etc.*
   [Unless distributed in connection with the special manufactures for which they are employed.]
4. *Machinery in general.*
5. *Machinery in motion.*

SECTION III.—FINE ARTS.

CLASS XXXIII.—PAINTINGS in oil, water colours, distemper wax, enamel, on glass, porcelain.

CLASS XXXIV.—SCULPTURE.—Modelling, carving, and chasing in marble, stone, wood, terra cotta, metal, ivory, glass, shell, precious stones, and other materials.

CLASS XXXV. — ENGRAVING, ETCHING, LITHOGRAPHY, PHOTOGRAPHY, ETC.

CLASS XXXVI. — ARCHITECTURAL DESIGNS, DRAWINGS, MODELS, ETC.

CLASS XXXVII.—ART DESIGNS FOR MANUFACTURES.

1. For all kinds of decorative manufactures.
2. Tapestries, carpets, embroideries, shawls, lace, fans, etc., shown for the fine art of their design in form or colour, and not as manufactures.

CLASS XXXVIII.—REPRODUCTION OF WORKS OF ART.

Copies of ancient or mediæval pictures, mosaics, enamels, of ancient works of art, etc., in plaster, fictile, ivory, electrotype, etc.

The above classification is founded on that drawn up by H.M. Commissioners for the International Exhibition of 1862, but is modified so as to bring certain groups of an allied character into closer connection than was therein arranged, with the object of facilitating their study by visitors having a common interest in two or more branches of inter-related manufactures, while other groups of modern origin are more fully elaborated as to their details, where their scope is not fully comprehended by the public at large. Thus the literary, educational, philosophical, surgical, pharmaceutical, sanitary, and life and property preserving appliances are here arranged in succeeding classes, instead of being widely separated, as in the grouping of trades and manufactures in 1862. The necessarily numerous subdivisions of the educational department, contributed to by so many trades and manufactures, are here fully elaborated as a suggestion for the future, when it is to be hoped the respective groups of this class may be contributed to by all nations, and the collection displayed in one gallery. An international exchange of ideas on the methods and appliances for teaching in all departments of knowledge, under good organisation, would prove of great value, when our school boards are discussing schemes as to what to teach and how to teach. Under the thirty-eight classes specified in the above classification about 300 trades should find a place, the greater number of which are enumerated in alphabetical order in H.M. Commissioners' List, published in the *Society of Arts Journal*, Vol. IX., No. 458, August 30, 1861.

NOTABLE INVENTIONS AND INVENTORS.

XXV.—CHARLES BABBAGE, F.R.S.

BY JOHN TIMBS.

THIS celebrated mathematician and mechanician, one of the most active and original of original thinkers, and whose name has been known through the length and breadth of the kingdom for nearly half a century, was born on the 26th of December, 1792. His father, Mr. Benjamin Babbage, of Totnes, in Devonshire, came to London, and became a partner in the banking-house of Messrs. Praed, Mackworth, and Babbage. Little is known of Charles Babbage's early life; but it is stated that he was so weak in body and mind, that it was not considered worth while to send him to school, and he was left to ramble about the fields and commons; and it has been suggested that the ramblings of the child may have prepared the foundation for those habits of thought which formed the mathematician, while his early weakness may account for his irritability. On getting stronger, he was educated at the Totnes Grammar School, and then sent to the private school of the Rev. Stephen Freeman, of Forty Hill, near Enfield, from whom young Babbage imbibed an intense love of mathematics, and where he had for schoolfellows the late Captain Marryat, the novelist, and Mr. William Carr, of Brighton, who still (1871) survives.

At the usual age Mr. Babbage was entered at the University of Cambridge, and his name appears in the list of those who took their bachelor's degree from Peterhouse in the year 1814. It does not, however, figure in the Mathematical Tripos, he preferring to be Captain of the Poll to any honour but the Senior Wranglership, of which he knew Herschel to be sure. While, however, at Cambridge, he was distinguished by his efforts, in conjunction with Sir John Herschel and Dean Peacock, to introduce into that University, and thereby among the scientific men of the country in general, a knowledge of the refined analytic methods of mathematical reasoning which had so long prevailed on the Continent, whereas we in our insular position, for the most part, were content with what has been styled "the cramped domain of the ancient synthesis." Keeping this object steadily in view, in the first place the youthful triumvirate translated and edited the smaller treatise on the "Calculus" by Lacroix, with notes of their own, and an appendix (mainly, if not wholly, from the pen of Sir John Herschel) upon "Finite Differences." They next published a selection of the exercises on all parts of the "Infinitesimal Calculus," a volume which is still of great service to the mathematical student, in spite of more recent works with a similar aim. To this publication Mr. Babbage contributed an independent essay on a subject at that time quite new, the solution of "Functional Equations."

In 1828, Mr. Babbage was placed in Newton's chair as Lucasian Professor of Mathematics in his University, and he held that chair eleven years, but, it is believed, never lectured. He soon afterwards produced his "Tables of Logarithms," upon the preparation of which he bestowed the highest care. In order to diminish the fatigue of constantly picking out figures from black and white pages, he experimented upon tinted papers, and their effects upon the eye, the result being that his logarithms were partially printed upon green and fawn-coloured sheets. These logarithms were used in the calculations of the whole of the Trigonometrical Survey of Ireland, and in those of the English Survey from the period of their publication; they were also printed for foreign circulation.

In the year 1832 Mr. Babbage published his very popular work, "The Economy of Machinery and Manufactures," which presents a series of summarisations rarely approached. It originated in ten years' visits made to workshops and factories, in England and on the Continent, for the purpose of endeavouring to make himself acquainted with the various resources of mechanical art, when he was insensibly led to apply to them principles of generalisation which regulate the application of machinery to arts and manufactures, as most important either for understanding the action of machines, or enabling the memory to classify and arrange the facts connected with their employment. Or a still more lucid explanation of the object of the volume is—"to point out the effects and advantages which arise from the use of tools and machinery, to endeavour to classify their modes of action, and to trace both the causes and the consequences of applying machinery to supersede the skill and power of the human arm." Sometimes this talent of Mr. Babbage exhibited itself in unexpected directions. Thus, a writer in the *Athenæum* states:—"We have heard an eminent artist refer to an exposition of the principles of imitation in portrait painting, which Mr. Babbage addressed to him in the shape of a letter, and which our informant regards as the best essay on that branch of art which has ever come under his notice." This is, indeed, a charming work, and well do we remember reviewing it, nearly forty years since, and being strongly impressed with the talent and taste which made it "as entertaining as a fairy tale." It was translated into French, German, Italian, Spanish, and Russian. Four years later, Mr. Babbage wrote "The Ninth Bridgewater Treatise," a work designed by him at once to refute the opinion supposed to be implied and encouraged in the first volume of the "Bridgewater Series," that an ardent devotion to mathematical studies is unfavourable to a real religious faith, and also to give specimens of the defensive aid which the evidence of Christianity may receive from the science of numbers, if studied in a proper spirit. This is one of the best known of Mr. Babbage's works for its important social bearings.

The "Decline of Science," which Mr. Babbage published previous to the above work, was received in a different spirit; its statements were freely controverted, especially in a clever pamphlet published in 1831, and entitled "On the Alleged Decline of Science in England," by a foreigner, with a prefatory note by Faraday. The pamphlet contains but thirty-two pages, yet it disposes of the writer's argument in a compass rarely recognisable in controversies. The reader will find the question of the comparative national encouragement of science in England and in France, in a long quotation from Mr. Babbage's work, in the "Arcana of Science and Art," 1831, pp. 62—66. The same opinion was still further worked out by Mr. Babbage in a book on the Great Exhibition of 1851, which he published twenty years ago. He wrote also an autobiographical memoir, entitled "Passages in the Life of a Philosopher." Altogether, with a wonderful grasp of mind, he wrote nearly eighty papers for different learned societies and scientific periodicals.

We now approach Mr. Babbage's crowning scientific effort, the invention and partial construction of the famous calculating machine or engine, with which his name has long been associated, and will go down to posterity. Machines for performing arithmetical calculations were common before computations by the pen. The Roman *abacus* was the oldest instrument of this kind; it was employed in the south of Europe till the end of the fifteenth century, and in England to a later period. It consisted of counters, movable in parallel grooves, or on parallel wires, in a frame, and having the different denominations, as the units, tens, hundreds, etc., according to the grooves in which they were placed. In China, where the system is decimal, this instrument, called Schwampan, is used with great rapidity; and from the Chinese merchants, at the great fair of Novogorod, the Muscovites first learnt the use of the abacus, since it is at the present day the common mode of reckoning in the shops of Moscow. This is the simplest form of calculating machine.

Pascal, when scarcely nineteen years of age, constructed a machine for executing the ordinary operations of arithmetic; and of this he executed more than fifty models in ivory, ebony, and copper, before he completed it. But he experienced the usual neglect of cultivators of science: "the French monarch had, indeed, given him the exclusive privilege of his invention, the right of expending his time, his money, and his health, in perfecting a machine for the benefit of France and the world; but like a British patent bearing the great seal of England, it was not worth the wax which the royal insignia so needlessly adorned." (*North British Review*, No. 2.)

Pascal's machine had a resemblance, though faint, to that invented by Mr. Babbage. It was an assemblage of wheels and cylinders; on the convex surfaces of the latter were the numbers for performing the operations, as the addition and subtraction of sums of money, having the denominations of livres, sous, and deniers, for which may be substituted pounds, shillings, and pence; and to these denominations the numbers were adapted; attached to the axles of the cylinders were toothed wheels, which were turned by pointers; the additions being performed by means of the numbers in the lower series of the numbers on the cylinders, and the subtractions by means of the numbers in the upper series on the cylinders. Pascal's machine excited a considerable sensation throughout Europe, and six eminent men of science devoted all their mathematical and mechanical skill to improve Pascal's machine, but without success. In the excellent article on "Calculating Machines" in the "Penny Cyclopædia Supplement," it is remarked, "Where many sums of money are to be added together, some time may be saved by the use of such a machine; but the processes for subtraction, multiplication, and division would be more tedious, and perhaps more liable to error than those which are performed by the pen." Subsequently to the time of Pascal, Leibnitz invented a machine which is believed to have surpassed Pascal's both in ingenuity and power; but he left no detailed account of its complicated mechanism, and perhaps all that is known of it is, that by wheel-work the operations of multiplication and division could be performed without the successive additions or subtractions which would be required if Pascal's machine were used.

The possibility of constructing a piece of mechanism capable of performing certain operations on numbers we have shown to be by no means new; but never before or since has any scheme so gigantic as that of Mr. Babbage been anywhere imagined. While all previous contrivances performed only particular arithmetical operations under a sort of co-partnership between the man and the machine, in which the latter played a very humble part, the invention of Mr. Babbage actually substitutes mechanism in the place of man; and if carried on to the extent proposed, would constitute one of the most superb monuments of human ingenuity. It calculates astronomical, logarithmic, and navigation tables, as well as tables of the powers and products of numbers. It can integrate, too, innumerable equations of finite differences; and, in addition, "it does its work cheaply and quickly, it corrects whatever errors are accidentally committed, and it prints all its calculations!" (*North British Review*, No. 2.) It was intended not only to perform arithmetical operations with absolute certainty, but also to transfer the results immediately to copper plates, from which any number of copies may be printed without a possibility of error.

This grand invention of the age was first mentioned in a letter from Mr. Babbage to Sir Humphry Davy, dated July 3, 1822, in which he describes a small model of his engine for calculating differences (hence Mr. Babbage prefers to call it a "difference engine"), which produced figures at the rate of forty-four a minute, and performed with rapidity and precision all those calculations for which it is designed;" and Sir H. Davy witnessed and expressed his admiration of the engine. The letter was sent to the Treasury, and submitted to the Royal Society, when upon the recommendation of a committee, Mr. Babbage, at the desire of the Government, undertook, in 1823, to superintend the construction of such an engine. He bestowed his whole time upon the subject for many years, during which about £17,000 had been expended by the Government in the construction of the difference engine. A considerable part of this sum had been advanced by Mr. Babbage for the payment of the workmen, and was, of course, repaid; but it was never contemplated by either party that any portion of this sum should be appropriated to Mr. Babbage himself, nor did he receive a single shilling of the money, in any shape, for his invention, his time, or his services; a fact which Sir Robert Peel admitted to the House of Commons in March, 1843.

"Early in the year 1833, a small portion of the machine," Mr. Babbage tells us, in the "Ninth Bridgewater Treatise," "was put together, and it performed its work with all the precision which had been anticipated." In the previous year, Sir David Brewster, in his "Natural Magic," had borne testimony to the working of the engine in these words:—"Great as the power of mechanism is known to be, yet we venture to say that many of the most intelligent of our readers will scarcely admit it to be possible that astronomical and navigation tables can be accurately computed by machinery; that the machine may itself correct the errors which it may commit; and that the results of its calculations, when absolutely free from error, can be printed off, without the aid of human hands, or the operation of human intelligence. All this, however, Mr. Babbage's machine can do, and as I have had the advantage of seeing it actually calculate, and of studying its construction with Mr. Babbage himself, I am able to make the above statement on personal observation. . . . The greater part of the calculating machinery is already constructed, and exhibits workmanship of such extraordinary skill and beauty that nothing approaching to it has been witnessed. In order to execute it, particularly those parts of the apparatus which are dissimilar to any used in ordinary mechanical constructions, tools, and machinery of great expense and complexity have been invented and constructed, with contrivances of singular ingenuity. The drawings of this machinery, which form a large part of the work, and on which all the contrivances had been bestowed, and all the alterations made, cover *upwards of* 400 *square feet of surface.*"

Sir David Brewster, concluding with some observations upon "that class of individuals who envy all great men, and envy all great inventions," averred that Mr. Babbage's invention was not new, reminding them that "its function, in contradistinction to that of all other contrivances for calculating, is to embody in machinery the method of differences, which has never before been done; and the effects which it is capable of producing, and the works which in the course of a few years we expect to see it execute, will place it at an infinite distance from all other efforts of mechanical genius." We may here note that a popular account of Mr. Babbage's engine will be found in his interesting volume "On the Economy of Machinery and Manufactures," to which we have already referred.

Early in 1833, the construction of the difference engine was suspended, on account of some dissatisfaction with the workmen. Some twelve months after this, about October, 1834, writes Mr. Babbage, "I commenced the design of another and far more powerful engine. Many of the contrivances necessary for its performance have been discussed and drawn according to various principles, and all have been invented in more than one form. I consider them even in their present state [April, 1837] as susceptible of practical execution, but time, thought, and expense will probably improve them. The new engine will calculate the numerical value of any algebraic function; that, at any period previously fixed upon, or contingent on certain events, it will cease to tabulate that algebraic function, and commence the calculation of a different one, and that these changes may be repeated to any extent. The former engine would employ 120 figures in its calculations; the present is intended to compute with about 4,000."

The analytical engine, as this new machine was called, could not exist without inventing for it a method of mechanical addition possessed of the utmost simplicity. In fact, it was not until twenty different modes for performing the operation of addition had been designed and drawn, that the necessary degree of simplicity required for the analytical engine was ultimately attained. These new views acquired additional importance from their bearings on the difference engine, already partly executed for the Government, for if such simplifications should be discovered, it might happen that the analytical engine would execute with greater rapidity the calculations for which the difference engine was intended; or that the difference engine would itself be superseded by a far simpler mode of construction; and these views were subsequently completely realised. To have resumed the construction of the difference engine while these new views were withheld from the Government, would have been improper; yet the state of uncertainty in which these new views were involved, rendered any written communication respecting their probable bearing on that engine a matter of very great difficulty.

From the year 1833 to the close of 1842, Mr. Babbage repeatedly applied to the Government for its decision upon the subject. These applications were unavailing. Years of delay and anxiety followed each other, impairing those energies which were now directed to the invention of the analytical engine. Amid such distractions, the inventor steadily pursued his single purpose. The drawings and the notations were freely shown, and the great analytical engine was explained and discussed by some of the first philosophers of the day. Copies of the engravings were sent to the libraries of several public institutions. Throughout the whole of these labours, neither science, the institutions, nor the Government of the country, ever afforded the inventor the slightest encouragement! When the invention was noticed in the House of Commons, one single voice alone was raised in its favour. One night, when Mr. Wakley inquired of the Minister when it was likely the calculating machine would be completed, he was jocularly recommended to set the engine to *calculate!* During upwards of twenty years, Mr. Babbage maintained in his own house in Dorset Street, and at his own expense, an establishment for aiding him in carrying out his views, and in making experiments, which most materially assisted in improving the difference engine. When that work was suspended, he still continued his own inquiries, and having discovered principles of far wider extent, he ultimately embodied them in the analytical engine. The establishment necessary for the actual construction of the difference engine, and of the extensive drawings which it demanded, as well as for the formation of tools to overcome the novel difficulties of the case, and the drawings and notations of the analytical engine, gave occupation to a considerable number of workmen of the greatest skill during many years. To render the drawings of the difference engine intelligible, Mr. Babbage had invented a compact and comprehensive language (the mechanical notation) by which every contemporaneous or successive movement of the machine became known.

PRACTICAL APPLICATION OF THE FINE ARTS.—VII.

THE ART OF GLASS PAINTING.

By P. H. Delamotte, Professor of Drawing, King's College, London.

We now give two more illustrations of the way in which figures may be treated. In the one we have the head, in the other the figure. As will be perceived at once, the head in this case is more fully elaborated than in our last, and an amount of accessory and consequently of leading is introduced. We have here, too, a male head, that of an ecclesiastic; consequently a deeper tone of glass may be employed than would be befitting a female, especially a female of a rather delicate style of beauty; but the tone will not be so deep as if it were intended to represent an older or less refined style of face. Much depends upon the choice of appropriate glass, whether of tone, tint, or texture. Tone, to a great extent, depends upon the position in the general design; if the subject be a large one, upon the amount of shade or prominence to be given to the individual figure; for, as in the old tale, it is not only necessary to paint each individual grape aright, but the whole bunch must be arranged and toned. Tint must have reference to contrast with surrounding subjects, to the age and character of the person to be portrayed, and the various colours to be brought out by shade and stain. Texture, too, should have some connection with the style of beauty, but this must also be reckoned according to the position the window is to occupy, whether only slightly above the level of the spectator or at some considerable height.

We have, in our second paper, alluded to this consideration of position and adaptation to the intended site, but we cannot impress too strongly on the mind of the designer that the probable and commonest position of the spectator must be carefully provided for. We know that in theatrical scenes the perspective is so arranged as to afford a perfect illusion when seen from the centre of the house, but that if viewed from either side everything is more or less out of proportion and out of joint. With a window placed at a great height it must be the same. If a person on the floor, say, of a church, has to crane his neck up to an angle of 60° or more, the lines which to his eye would form a handsome and impressive countenance, would appear repulsive and ridiculous from the clerestory on the opposite side of nave or transept. These things must be considered, and when a satisfactory design has been accomplished it must be put *out of drawing* in order to give the purposed impression from a different stand-point. This may be done by calculation, by increasing all the perpendicular lines in a certain ratio, whilst keeping the horizontal measurements the same; or it may be accomplished by fixing a point at a certain height above the flat table on which the drawing is to be made, suspending the original design opposite to this, and copying as fairly as possible the effect required upon the surface inclined at the required angle to the eye. It should be remembered in the former method, however, that the upper parts of the design have to be exaggerated rather more than the lower.

This alteration of drawing will be found very advantageous in one respect, and that is, that long, narrow windows, or lights, so common in Gothic buildings, can, when placed at a height, be made available for designs which otherwise would be quite unsuitable for them.

Our glass being chosen, and the design brought into the required shape, let us now proceed to the actual painting. The outline, as before, can be traced, and in this part of the work the bold, vigorous work of the draughtsman, who feels sure of every line, is easily distinguished from that of the mere copyist from the design of another. It is in this vigorous treatment of the drawing that oftentimes the amateur glass painter, if he be really an artist, and certain of his powers of delineating what he intends, so far excels the mere mechanical manufacturing workman, who is far more skilled in the technicalities of his art. The workman, therefore, who would compete for honour and fame in the practice of this art, must really study fine art; he must cultivate his taste, and educate his hand and eye by every means within his reach; and he will not find that the time spent in the art-school at conscientious work, with pencil or crayon, will be thrown away, even from a pecuniary point of view.

The outline being fixed in, an amount of stippled shading must be laid on down the side of the face and neck, but this must be kept light, so that afterwards another coating of shade may be added, which shall partake something more of the character of the lines by which this shading is represented in our wood-cut. The great object is to keep up the transparency of the glass, and this is done partially in the stippling, by the interstices of light which penetrate where the brush touches the glass, but it is still better accomplished by cross-hatching of lines. In fact, the shading of glass very closely resembles the corresponding work in a good chalk drawing. First, the stippling answers to the rubbing in of shade with the stump, and, like it, can be modified to a certain extent by rubbing out lights when the oxide is dry; then the decided chalk lines are represented by hatching lines, made with the long flexible brush; and finally, even the high lights may be slightly imitated by grinding away in some cases the surface of the glass, or by the use of acid.

The shading being fairly accomplished, the stain may be put in, and in this again there is room and necessity for much judgment. It will not do that all the hair should be of the same hue, and however enticing the colour may be, it will not always be suitable that the female figures should be all alike endowed with the fashionable hue of the day. Judgment, experience, and a knowledge of the results of various combinations alone will give what is requisite to cause an agreeable variety.

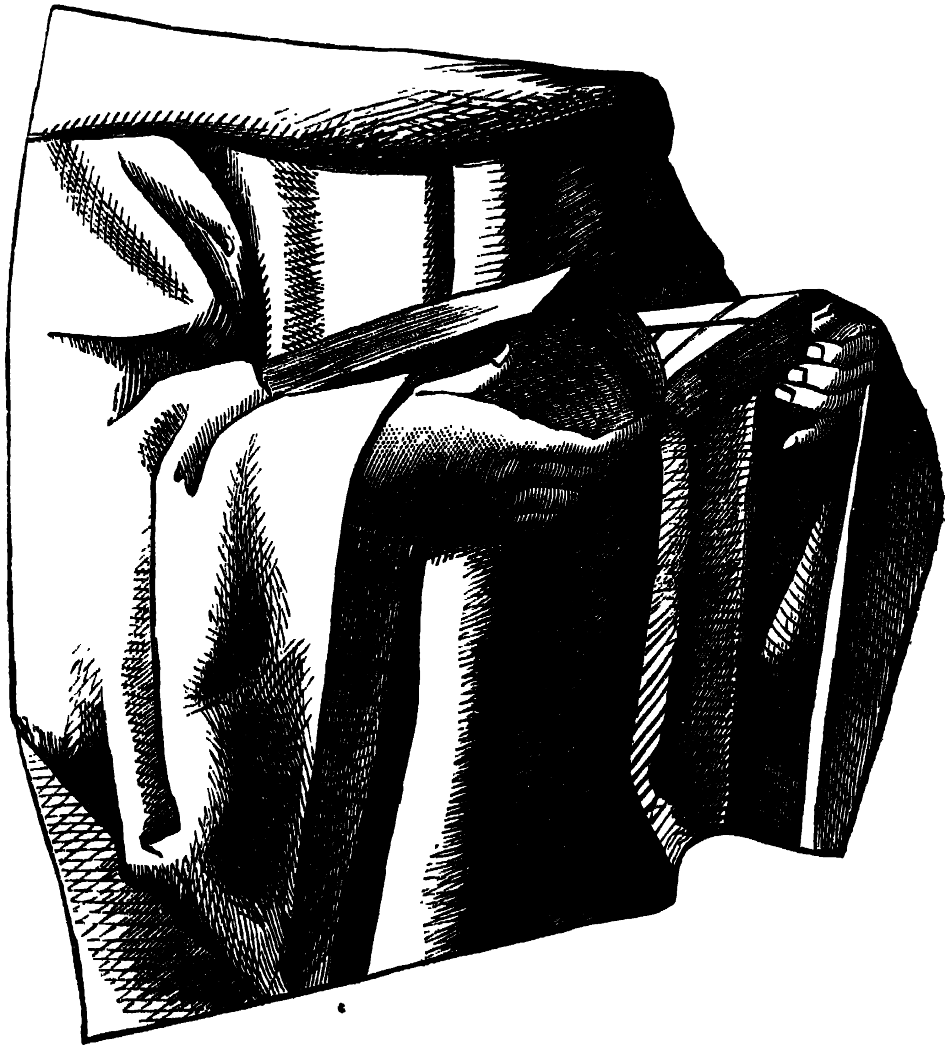

Fig. 12.—FIGURE WITHOUT A HEAD HOLDING A BOOK.

The gems upon the bishop's mitre (Fig. 13) have been represented sometimes by the addition of knobs of coloured glass attached to the surface of the glass. This practice, however, is not common, nor is it always desirable. There is considerable doubt whether the additions will always adhere sufficiently to last as long as the window endures, and even if there were no other objection, the process partakes too much of the nature of a trick of art to be altogether pleasing.

Our other illustration (Fig. 12), taken from the singing men in Cologne Cathedral, shows the one point in which the Germans excel, ease of posture and careful and good drawing. The hands are natural and unexaggerated, the book lies open for use, and the drapery falls in massive and intelligible folds. There is no straining after effect, and the success leaves one in a comfortable frame of mind, neither anxious to discover the answer to unsolved enigmas, nor elated at the discovery of ideas implied but not developed.

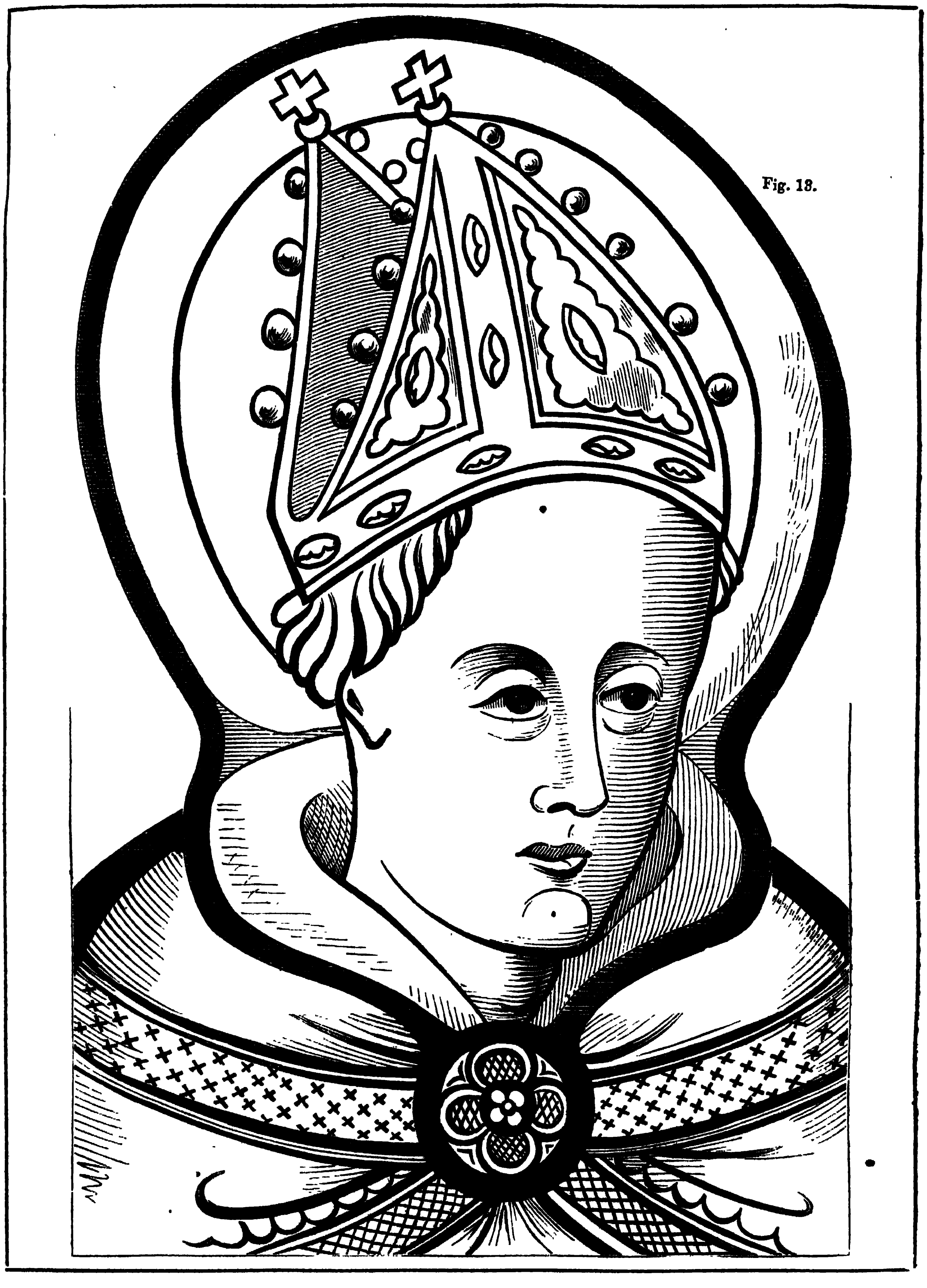

Fig. 18.

SOLDIERING.—II.

BY A STAFF OFFICER.

OBJECT OF WAR—MORAL FORCE—SYSTEMS OF RECRUITING ARMIES.

In studying, then, the process by which an army is organised, it will be necessary to keep very clearly in view the double purpose of perfecting the material structure, and of infusing into it the spirit which is both to render it powerful, and to place it perfectly in the hands of him who rules it. The one purpose is in fact to develop material, the other that which for want of a better name we are obliged to call "moral force."

Greatly as modern wars are always affected by constantly progressive material improvements, and important as it is therefore to inquire with reference to any army to what extent preparation has been made in its organisation for taking full advantage of these, nevertheless it will be necessary for us to consider even more carefully to what extent the moral force has been developed. For, in the first place, the development of that force is the more difficult part of the problem, and, in the second, the difference between the most perfect and the most imperfect development is less easily discovered till it is too late.

We may cite the universal experience of history to prove that ultimately success depends on the extent to which the power of the *armies* for fighting has been broken on one side or the other. The numerical difference between the lists of killed and wounded of the victors and vanquished is usually very slight. Very frequently the victors have up to the moment of complete victory suffered most. In what then has the great loss of power sustained by the vanquished consisted? In the capacity for cohesion for united, continuous, and effective action. Now this capacity constitutes no small part of that which we mean by moral force. All this is equally true in the detail of fighting; for the best evidence appears to show that the accounts of large bodies of men whose material opposition has continued up to the last moment when it was possible to offer it are very nearly all fables. Long before men actually run they have under the circumstances of fight become so "demoralised" as to cease to fire with effect. Now to quote from a pamphlet which, as it was used in the instruction of the officers of the victors in the late gigantic struggle up to the moment when they were entering upon it, and after they had recently won a campaign, their success in which Europe was inclined to attribute chiefly to the mechanical improvements which they had adopted, may be cited as proof that what we are urging is not based on any sentimental affection for the mere term "moral force," but on practical deduction from the actual study of war. "What, for instance, is the good of the best-rifle in the hands of the most practised shot if the eye is blinded and the hand trembling with excitement? It is on the moral force of the troops, then, that the fate of battles mainly depends; and no tactical study can be of any real value which does not take it into account, or which subordinates it to mere questions of form or system."*

Nevertheless, the forms and the systems may very largely indeed affect the extent to which we can succeed in developing the "moral force" which we require in our army, and this we shall immediately have occasion to note as we proceed to examine the distinctions between different methods of organisation. In the first place, then, since in order to create our army at all, we must have some means of obtaining a regular supply of men, and since "moral force can hardly be created, the germs of it at least must exist in the individual soldier," it becomes in the last degree important to consider the effect which different systems of enlistment are likely to have in supplying an army with these "germs" of moral force. It is clear that we are much more likely to be unaware of the influence which is thus being produced than we are to be unconscious of the effect upon the mere numbers which we obtain.

The means by which armies have been recruited have differed somewhat in each period of history, and in each country in that period, but it will be convenient at present to limit the statement to the systems of the present day or of recent wars. We may include all systems under the heads of the "voluntary" method and the "compulsory." The latter, the "compulsory," is, however, of two very distinct kinds, which may be conveniently classed as "conscription" and "universal service:" the former, that which has till lately been the system pursued in France; the latter, that which has been almost forced on all Continental powers by the brilliant success which has attended its adoption by Prussia. The principles on which the voluntary and the compulsory systems are severally based are, the one, that it is best for the general good that the service of the State should be supplied at the ordinary market rate; the other, that every citizen has a duty which he is bound to perform, and from which he is only to be excused on general grounds of high State policy. The broad distinction between the "universal service" system and that of conscription is that while the principle on which both are based is carried out in the one in its integrity, in the other it is in practice so modified that its essential features disappear.

Under the system of "universal service" as understood in Prussia, every one who arrives at the age at which he is fit to enter the military service has to present himself to be medically examined for the army. It does not in the least follow that his social position will be violently changed. If he has certain social advantages of position he can retain these, provided he shows that the service which he is able to render the State is proportionally valuable. But he must ultimately prove by rigid tests that his social position has been so used as to enable him to offer more valuable service in war, either as an officer or volunteer soldier, than he could by entering the ranks at once as a private. Except for sons who are the sole support of widows or of parents unable to support themselves, there is no exemption on the ground of personal inconvenience. From the number who present themselves, those are selected who from their *physique* are best qualified for the work required of them. Those who after they have been allowed full time for development are not selected for the army, are kept as a reserve, and sufficiently trained to fill up vacancies should their services be wanted. Thus though the number actually to be taken into the service is fixed for each year, according to what is considered necessary to supply the required force, the State distinctly exercises its claim to the service of all, and makes its own selection of those who are best suited to fulfil the work which it requires. None are permitted to fly of their own choice from the service as from a plague. It is only in the last resort, when the number of those who reach the highest standard of efficiency is too great for convenient use, that a ballot is resorted to which determines whether the man shall join the *ersatz* reserve or the active army. Not, therefore, to be passed for the service is in some sort a mark of at least physical inferiority.

On the other hand, under the late French system, the number of the army having been fixed, the selection of those who were to be taken was by ballot. An immense number of special exemptions were permitted, most of them based on considerations as to the personal convenience of the exempted. Hence, to be exempted became a privilege, and if that privilege could be obtained by personal deformity, it was then also a distinction on which to be congratulated, not a disgrace which courtesy would induce others to pass by unnoticed; the ballot became simply a means of determining who should not escape like the more lucky ones. It seemed natural that if any were such vagabonds as to be willing for a consideration to undertake an unpleasant lot, they should be permitted to do so instead of those who were rich enough to escape from it; societies were formed which insured their subscribers against being taken for the army as against any other piece of misfortune. This arrangement being at a later date abolished, in consequence of the proved inferiority in all respects of the substitutes provided, money was paid to the government instead of the companies by the man who wished to be exempt; the only difference being, that the imperial officials, not being under the same restraint as the societies, pocketed the money, and did not provide any substitutes.

If we take all these facts into consideration, it becomes clear enough that the difference in the material prepared for the two armies did not consist by any means only in the disproportion of numbers, but that the respective systems tended to produce within the army itself very different feelings as to the duties which each man owed to the service to which he belonged.

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* "About Tactics," by Captain Laymann, Instructor in Tactics at the Royal War School, Cassel. Translated by Captain E. M. Jones, 20th Foot, F.R.G.S.

Comparing now these two with the so-called voluntary system, it is extremely important to note the difference which exists between names and facts. For since one great point is to get men who are willing to learn their business, surely a "voluntary" must be better than a "compulsory" system. But does a man enlist with a much more hearty love of his profession who is driven into it by hunger than by a law which he finds pressing with equal justice upon all his acquaintances high and low? Or supposing again that by a misconception of the nature of the work you intend afterwards to call upon him to do, a man is induced to enter the army, who fancied he was going at once to enter upon a very splendid career, and finds that he has to obey orders and scrub tables, will the service you obtain from him be very willing?

Now both these dangers surround the circumstances of a voluntary service. There is constant danger, on the one hand, lest the material with which you have to deal should become very inferior in consequence of the number of men who enter your service because their characters render them unfit for other work. On the other hand, in a country where those who do not intend themselves to have any connection with the army, have no reason to trouble themselves further about it, as all must do where "universal service" prevails, there is very apt to be an almost absolute ignorance prevailing as to what goes on within it. Hence a desire arises, which is sure with most of the classes who cherish it to lead to bitter disappointment, that they should be able to enter the ranks of an army so ordered that it will provide them with an all but certain and splendid career. That the spirit with which this class would infect the mass is distinctly mischievous towards the objects which are most essential in army organisation, we shall have abundant occasion to note as we proceed. "La carrière ouverte aux talents" is the typical cry. It essentially represents that disintegrating selfishness which split up the French army; can accurately be translated into English only as "universal struggle for place;" and is directly opposed to that principle with which it is often confounded, that the one great object to be secured is that the nation shall be provided with the best obtainable servants, each for their special work, and that no personal or class disadvantages shall interfere with the selection. The points, therefore, which with a voluntary service appears most essential, in order that its best features may be fully developed, are that the most perfect possible means shall be provided for enlightening those who have to select their profession as to the nature of the service they will adopt if they enter the army; that the conditions shall be as attractive as they can be made irrespective of pay, without injuring the service itself, in order that the best possible class of recruits may be obtained; but that the principle shall be rigidly enforced, that the good of the service must in all things be made the primary consideration, and that those who enter must be taught that they must volunteer to contribute their quantum to the efficiency of the whole, and that all personal considerations are to be made subsidiary to that. If these conditions are understood beforehand, the principle of voluntary service has then this immense advantage over the compulsory, that the same elective process is brought into play which exists with other professions, namely, that each man selects the one for which he believes himself to be the most fitted, and that he is subject to no slight private criticism in the matter by those who know him best. Very great efforts have been made of late years in England to introduce these latter advantages into our system. The old false plan of public-house enlistment by puffing sergeants and high bounties has been given up. Plain placards are now printed to show what the actual terms are on which a soldier enlists, stating in the fairest possible manner what prospects of pay, etc., he has before him. Various means, such as the creation of reading-rooms, etc., have been devised to give him the means both of amusement and self-instruction.

As to the obtaining of the number of men we require, that is after all in the main a question of how many we *do* require, and is one which must be answered differently for every country. Wisely or unwisely, it has at present been left in England a question of purely private speculation, and no authoritative declaration has been issued on the subject, though it is reported that a committee appointed to investigate the question has recommended that we should be always ready to put into the field anywhere a body of about 60,000 men fully equipped, and that we should have available for home service an effectively equipped body of 350,000 men, 200,000 of whom should be able to take the field. It is hardly necessary to say that at present we have no force of the kind, though in what respect our deficiencies are most pressing will become clearer as we proceed. In any case, at present no evidence has been forthcoming to show that in mere numbers it will be impossible to satisfy our requirements without resorting to compulsory service, though there is very considerable danger lest, from not having made up our minds clearly as to the force we wish to have available, we should be obliged suddenly to increase the quantity at the expense of the quality of our recruits—a process with which we are all familiar under the smooth sounding title of "lowering the standard of enlistment;" that is to say, admitting unformed, weakly men, because we cannot get well-formed, strong ones, the mere difference in the height allowed not at all representing the really important difference between the men. It is as an attempt to meet this difficulty that the system of draughting men off into the reserves has been instituted, in order that whilst maintaining strictly the same standard we may, when we obtain an excess of men, pass them into our reserve, and so continue to enlarge, without considerable expense, the number of men of proper *physique* on whom we can rely in case of any sudden necessity. It must be remembered, moreover, that our requirements are altogether different in kind from those of Continental nations, for while we are not exposed to the same danger of invasion as they are, so long as our navy is mistress of the sea, we have far distant possessions to defend, the garrisoning of which is by far the severest task which our army has to undertake. Since you can scarcely require a man compulsorily to expatriate himself for half a life, it appears certain that even the most eager advocates of compulsory service would not propose to extend its provisions to the whole army in the same manner in which that is done in Prussia; it is clear, therefore, that entirely new conditions come into play. In any case, the relative advantages of the two systems, in so far as the mere provision of the proper numbers is concerned, is a question almost entirely, as it has been well said, of the nature of the foreign, Indian, and colonial policy of the country; the numbers required, and therefore the possibility of obtaining them under a voluntary system, varying almost indefinitely in accordance with the different principles which we adopt on those subjects.

Passing to an inquiry into the relative cost of the two systems, it is obvious at once that if you insist on a man's giving you his service for any rate of pay you like to fix there will be a much smaller bill for total expenses than if you are obliged to pay all whom you employ at the ordinary market rate. It by no means follows that the real cost to the whole country will be less; for you have, in fact, been exacting from those whom you employ a very heavy tax indeed in addition to that which appears in your estimates. Each man who has had to serve for less than he otherwise would be earning has contributed just that difference between the pay he has received and the pay he would otherwise have received to the coffers of the State. In relative estimates between the cost of the Prussian army and our own this is almost invariably forgotten. Mr. Cardwell quoted (17th of February, 1871) from a report which very ably pointed out how this acted in the case of France, where substitutes being allowed, those who wished to escape had each to pay about £100, which of course helped to supply the cost of the army, and was an immense additional tax on the country most unequally levied. But it is obvious that where no substitutes are allowed the tax actually levied is much heavier, for this £100 only represents what large numbers of men were glad to pay in order to escape the yet heavier fine to them of being obliged to sacrifice their other opportunities of earning a living. Moreover, looking at the question in a larger economical point of view, the pecuniary loss which the countrys ustains from losing the services of many men from situations in which they largely contribute to increase the general wealth, and employing them in positions which others of less education and faculty could equally well, have fulfilled, is an element which must be taken very seriously into the account.

TECHNICAL DRAWING.—LVII.

GOTHIC STONEWORK.

DECORATED ENGLISH CAPITALS.

THESE, as a rule, follow the contour of the pier in clustered columns, and are either bell-shaped or octagonal. They are frequently only moulded, presenting rounds, ogees, and hollows, in which the ball-flower (Fig. 496) or square flower (Fig. 497), the prevailing ornaments of the period, are set. The abacus is either circular or polygonal in plan, and its mouldings are composed of rounds frequently with an overlap of ogees and hollows. The foliage is gracefully wreathed around the bell, instead of rising direct from the neck moulding. The difference will be at once understood on comparing Fig. 498, from York Cathedral, with the group of capitals in Fig. 479. The leaves of oak, maple, vine, ivy, strawberry, hazel, ferns, etc., are all so beautifully rendered as to give evidence of their having been studied directly from nature. The oak seems to have been an especial favourite. Figs. 499 and 500, crockets from Hereford and Lincoln Cathedrals, and Figs. 501 and 502, finials from Cherrington Church and York Cathedral, are beautiful examples of the application of natural foliage, and illustrate the development of these ornamental features at this period.

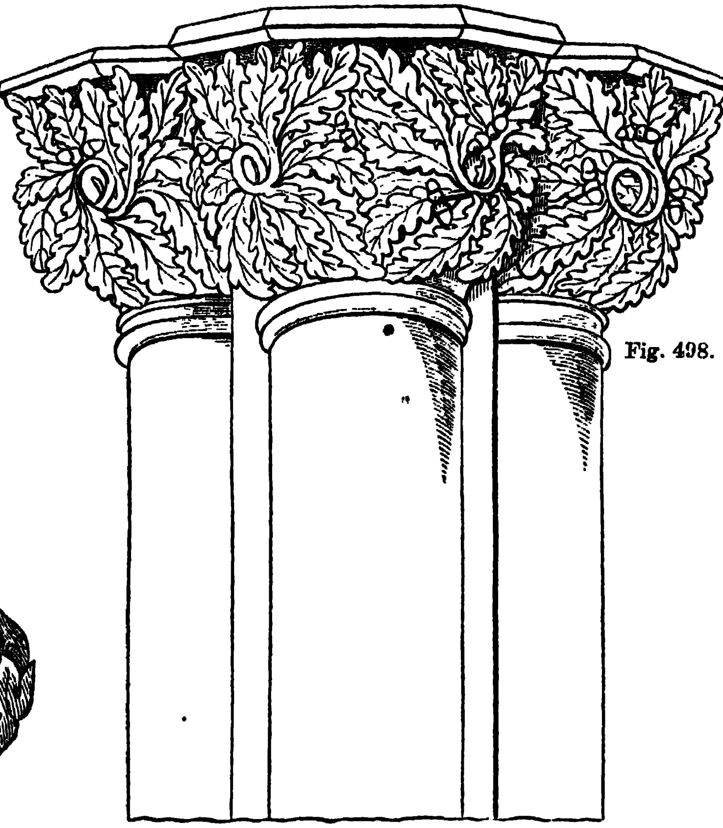


Fig. 498.

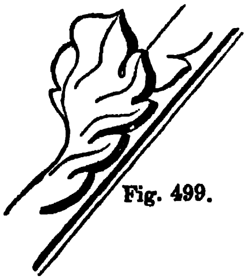


Fig. 499.

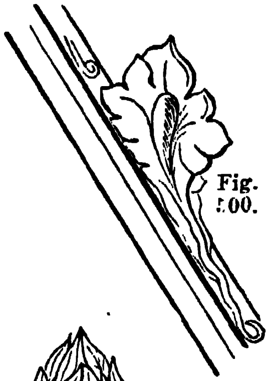


Fig. 500.

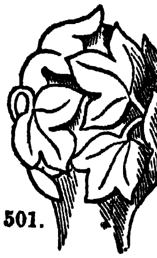


Fig. 501.

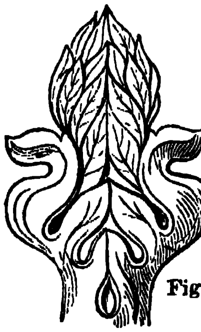


Fig. 502.

Fig. 496.

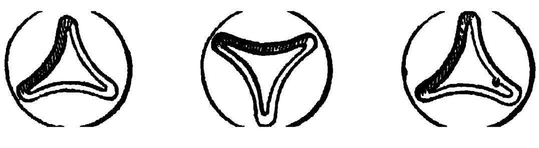
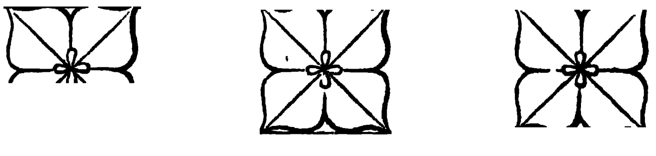


Fig. 497.



The doorways of this style possess very much the same features as in the last, but the mouldings, jamb-shafts, etc., are more slender, less undercut, and generally of finer proportions; the hollows being often filled with the ball-flower and square flower, applied in the same manner as the dog-tooth was in the Early English. The jamb-shafts differ from those used in the last period in being constantly engaged. Many doorways, however, are without pillars, being entirely composed of mouldings which are continuous with those in the architrave. The door-arches are frequently surmounted by a triangular or ogee canopy, ornamented with crockets and a finial, the spandrel being filled with sculpture of various kinds.

The large doors of this period are sometimes double, though not as generally so as in the last style; but the single doorways of the Decorated period are often nearly as large as the double ones of the Early English. On the sides of the doorways small buttresses or niches are sometimes placed, and in some a series of niches, with statues, are carried up like a hollow moulding; whilst in others, doubly foliated tracery hanging freely from one of the outer mouldings, gives a richness superior to any other decoration.

DECORATED ENGLISH WINDOWS.

These are usually large, and contain from two to seven lights; but there are also windows of single lights, of less elongated form than in the Early English period.

The variation from the character of the last period is here distinctly marked, first, in the employment of mullions instead of shafts with capitals and bases, but more especially in the full development of tracery.

It will be remembered that tracery originated in the necessity for piercing the portion of the wall which was left vacant when two lights were gathered under a single-arched dripstone, and thus the whole of the elementary tracery was necessarily in one plane, consisting merely of apertures in a flat surface. As the principle of window-tracery, however, became established, the mullions were recessed from the face of the wall in which the window-arch was pierced, and the fine effect thus produced was, as the art progressed, speedily enhanced by the introduction of distinct orders of mullions, and by recessing certain portions of the tracery from the face of the primary mullions and their corresponding tracery bars.* The distinct planes of tracery and mullions thus produced constitute one of the most beautiful features in Gothic windows.

Decorated window tracery is divided into geometrical and flowing. In the former the tracery consists of combinations of lines producing numerous geometrical figures—curvilinear, triangles, lozenges, etc. etc., and others based on them, and combined with circles, as the trefoil, based on the triangle; the quatrefoil, on the square; the cinquefoil, on the pentagon; the hexafoil, on the hexagon, etc. In the flowing tracery these figures, though still employed as a basis, are not each completed in themselves, so as to stand out individually; but they merge into each other, thus producing a blending of forms, and resulting in what has been called "flame-like compartments."

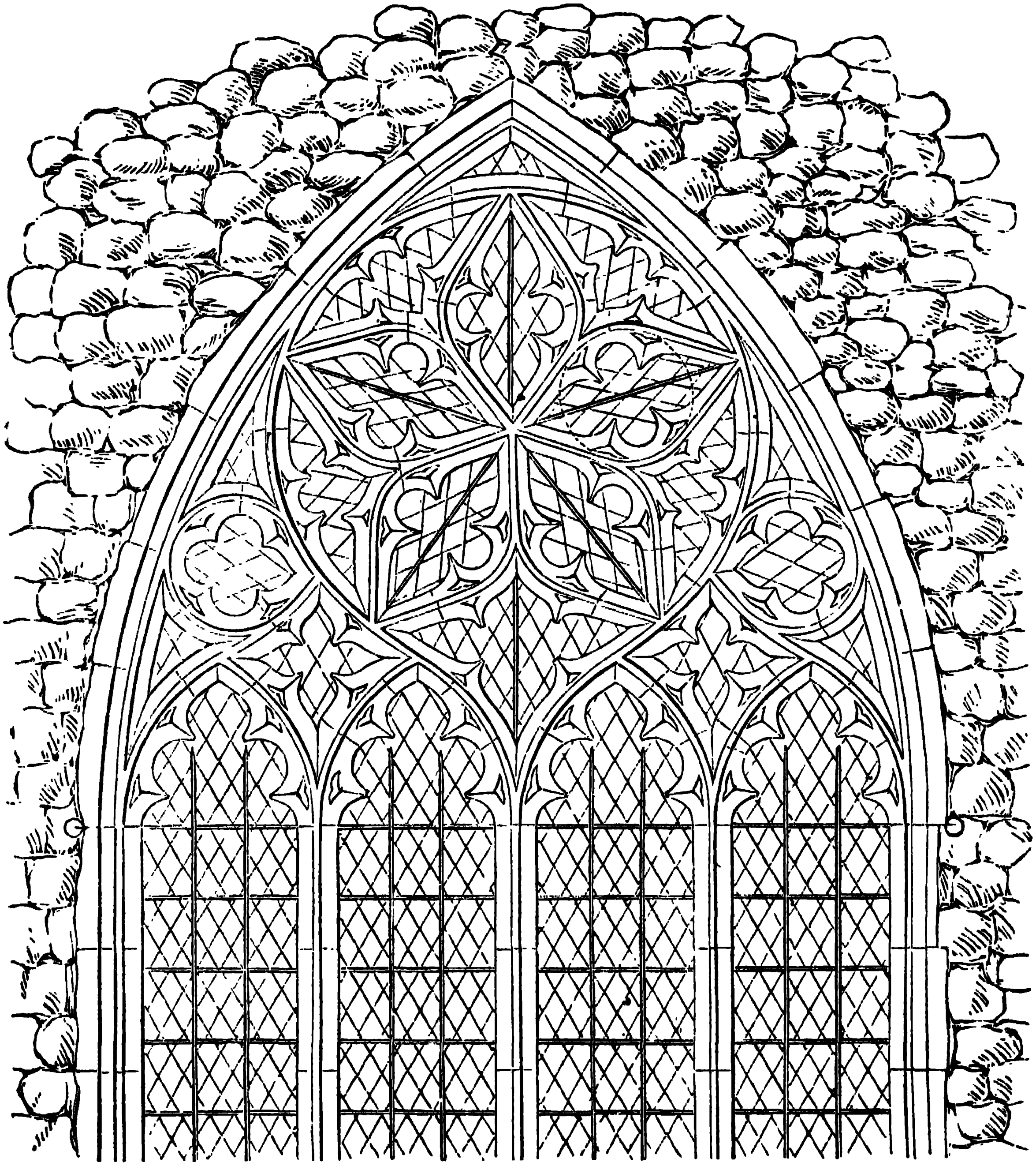


Fig. 503.—WINDOW FROM BOUGHTON ALUPH CHURCH, KENT.

In its most perfect state, geometrical tracery invariably exhibits some large figure of a distinct and decided character, which occupies the entire upper part of the window-head. This figure is generally a circle, itself foliated and cusped, or subdivided by smaller geometrical figures, in most cases similarly enriched; or it is formed by tracery bars diverging from the head of the central light in such a manner as to resemble the upper portion of the window arch inverted, and containing ornamental work of the same character as that in the large circles.

The window in Fig. 503 is from Boughton Aluph Church, Kent, and is a good, though not a rich, specimen of geometrical tracery. The figure on which the central portion of the head is based has already been given in lessons in "Practical Geometry applied to Linear Drawing."

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* *Tracery bars* are those portions of the masonry of a window-head which mark out the principal figures of the design. From these the minor and more strictly decorative parts of the stonework may be distinguishable under the name of "form pieces."—*Willis's "Nomenclature."*

PHOTOGRAPHY.—IV.

By J. C. Leake.

OPERATIONS IN DARK ROOM FOR SENSITISING PLATES—EXPOSURE OF PLATES FOR RECEPTION OF PHOTOGRAPH—DEVELOPMENT OF IMAGE—FIXING OF IMAGE.

The plate will now be ready for immersion in the sensitising bath of nitrate of silver; and from this time forward, until the picture is fixed, the whole of the operations must be conducted in the yellow non-actinic light of the dark-room, with the exception, of course, of the exposure to light in the camera. The yellow shutter of the room being closed, the plate may be sensitised by placing it with the lower coated edge upon the ledge of the dipper, and lowering it steadily and quickly down into the bath solution. Like the operation of coating, this also requires some skill and practice in order to effect it properly. The plate must be lowered quickly and regularly into the solution, as if the slightest jerk be imparted, or any hesitation be made, the result will be that a straight line, corresponding with the surface of the solution, will be left upon the plate, which, in the finished picture, will appear as if the glass was cracked at that point. After remaining at rest in the bath for some two or three minutes, the plate should be lifted by means of the dipper, and raised and lowered alternately ten or twenty times, in order to facilitate the escape of the ether and alcohol retained in the film. It will, at this stage, be observed that the surface of the film presents a somewhat greasy appearance, from the fact that the nitrate-of-silver solution does not mix freely with the alcohol and ether in the collodion. As soon as this resistance has been partially overcome, the position of the plate should be reversed upon the dipper, and the movement resumed until the solution flows in a smooth and even sheet over the whole surface. When this occurs the plate is sensitive to the action of light, and is ready for exposure in the camera. The process above described will have produced a very marked difference in the appearance of the plate. The transparency will now have given place to a creaminess and semi-opacity, owing to the combination of iodides and bromides contained in the collodion with the silver in the bath solution, the result being a film of bromo-iodide of silver of most exquisite sensitiveness to the action of the light.

While the plate has been in the nitrate bath, the dark slide of the camera should have been dusted, and wiped out with a damp cloth, and a few folds of clean blotting-paper laid upon the operating-table at the foot of the bath. These preparations made, the plate may be lifted out of the solution, and, after draining a few moments into the bath, be placed upon one end upon the blotting-paper, in order that all the superfluous moisture may drain off its surface. The back of the plate should then be carefully wiped with a tuft of soft paper, and the plate placed in the dark slide with its sensitive surface inwards. It is a good plan to insert a sheet of red blotting-paper at the back of the plate in the slide, in order that it may absorb any of the silver solution which may drain out of the film during exposure. It will be scarcely necessary to add, that the utmost care must be exercised in all these operations, in order that the sensitive surface be not injured, as it would be by the slightest touch either of the finger, or any substance whatever. After the sensitised plate has been placed in the slide, no time should be lost in exposing it to the action of light in the camera. It is true that it will retain its sensitiveness for perhaps half an hour after the removal from the bath, but it is at least running a considerable risk of failure, from stains caused by the partial drying of the films, if more than half that time be allowed to elapse between the sensitising and developing processes. Plenty of time may be occupied in exposure for all practical purposes, but none should be wasted or lost.

Before removing the slide containing the plate from the dark room, it should be lightly wrapped in a cloth of some opaque material, in order to shield it from any stray ray of light which might find its way to the sensitive surface and cause "fogging." The slide should be brought to and from the camera in the same position in which it was placed when the plate was inserted; and on no account must it be reversed, or knocked about, if the utmost perfection be required in the resulting picture. On arrival at the camera the focussing-screen should be removed, and the cap placed upon the tube holding the lens; the slide with the sensitive plate should then be inserted in the groove from which the screen has been taken, and the cloth thrown over the whole of the camera, of course, with the exception of the lens. The hand should then be inserted under the cloth, and the sliding-shutter gently and steadily lifted to its full extent. All will now be ready for the actual exposure of the plate to light, and after allowing a few seconds to elapse, in order that any vibration caused by the adjustment of the slide may subside, the cap may be gently removed and the plate exposed. The time during which this exposure is to be continued cannot be definitely given, as it varies with the aperture of the lens, the colour and lighting of the object to be photographed, the nature and character of the light, and many other matters. We may, however, suggest that, for an ordinary brick or stone building, partly in sunlight and partly in shade, with a lens of six inches focal length and an aperture of a quarter of an inch, the time of exposure necessary will be from twenty to fifty seconds. The only test of this matter will be the development of the image, of which we shall treat presently. When the exposure is completed, the cap should be replaced, the slide closed, and the plate removed to the dark-room for development, with precisely the same precautions as were before observed in bringing it for exposure.

Upon arrival in the dark-room, the plate must be removed from the slide and held in the left hand, precisely as during the process of coating with collodion. In the right hand the glass containing the iron developing solution should be taken, and the fluid should be spread from the lower right-hand corner completely over the plate with one quick and even sweep. There is no occasion to be sparing with the developing solution, and the important point here is to completely cover the whole surface with one application of the solution. If any hesitation be made in effecting this, from an insufficient quantity of solution, or from improper or imperfect spreading of it, lines and stains will be caused similar to those produced by hesitation in lowering the plate into the sensitising bath, and the picture will be spoiled. If the exposure in the camera has been properly timed, in a very few seconds after the developing solution has been applied the sensitive surface which, upon removal from the camera-slide bore no trace of an image, will begin to change in appearance; the highest lights, those parts upon which the light has acted most strongly, showing signs of becoming darker. The developing fluid must be kept in motion over the plate by rocking it backwards and forwards, so that the solution may flow equally over the whole surface. Gradually the whole details of the picture will appear; the highest light—such, for instance, as the sky—assuming a semi-opaque character, while in the deepest shadows the film of iodide of silver will remain nearly unaltered in appearance. If necessary, a second application of the developer may be made; but if a proper exposure to light has been given this is seldom required. When the whole of the details of the picture have been developed, the iron developing solution must be washed off, taking care not to disturb the film, which, it should be remembered, is exceedingly delicate, and liable to be removed from the glass by any violent treatment. The proper place in the dark-room in which the process of development may be conducted is immediately in front of the window, in order that the progress of the work may be examined by light transmitted through the plate. If the image be now examined, it will be observed that it is entirely reversed, the sky being dark and the shadows light; the proportion of light and shade, being, however, accurately preserved. If there should be sufficient density in the deposit thus formed, the operation of making the negative would be complete; but where the image is produced upon bromo-iodised collodion and developed with iron this is seldom the case, the negative being generally very soft and full of detail, but without density sufficient to resist the light during the process of printing. A second treatment is therefore necessary, in order to render the negative fit for printing, and add a sufficient thickness or opacity for the purpose. In order to effect this the solution of pyrogallic acid is employed as follows:—After a thorough washing of the plate and the complete removal of the iron solution, the second developer—or more properly the intensifying solution—is poured over the plate several times until it flows quite evenly upon the surface. A few drops of the ten-grain solution of nitrate of silver should then be added, and the mixed solutions applied as before. A rapid acquisition of density will be the result, and when the sky and the lights of the picture are so opaque as to only allow the outline of the finger applied to the back of the plate to be seen through them, the application of the fluid to the surface should be discontinued, and the solution washed off as quickly as possible. In ordinary cases, one application of the re-developer will be sufficient, but it may be continued as often as necessary, renewing the solution as soon as it becomes discoloured. Beginners often make their negatives too intense; and we should advise the tyro to obtain a good printing negative, by which he could guide himself in his work in this important particular.

The only chemical process now remaining to be effected is that of fixing the image, or dissolving out the unaltered portions of the sensitive film. This is a very easy and simple affair, in which there is but little risk of failure. If the hyposulphite of soda be used (which we should advise), the plate should be placed upon the ledge of the dipper, precisely as in the sensitising process, and immersed in the solution, where it should be left during some five or ten minutes. Upon removal from this bath, it will be found that the unaltered iodide of silver has been dissolved, and that the deepest shadows almost resemble the bare glass. If this be the case, and the high lights present a creamy appearance, and are semi-opaque, the operation may be considered successful, and the negative fit for printing. The hyposulphite solution must be very thoroughly washed off with a copious supply of water, and when the film is dry the negative will be fit for varnishing. If the cyanide of potassium is employed for fixing the image, it should be poured upon the plate and carefully watched, being washed off thoroughly as soon as the iodide is dissolved, or it will attack and dissolve the image itself.

When the film is thoroughly dry, the plate should be varnished before attempting to print from it, or it will inevitably be destroyed. The negative should be held in front of a clear fire until it is quite warm, but not hot. It should then be held by one corner and coated with varnish, exactly as it was covered with collodion, and with the same care. The varnish will dry into a bright, hard, and glossy surface, when the negative picture may be considered complete and ready for printing from.

For the sake of clearness we have avoided all mention of failures; but as these will most probably occur in one or other of the various stages, we will consider them and their causes and remedies in another chapter.

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FISH CULTURE—IV.

By Greville Fennell.

ARTIFICIAL FECUNDATION AND INCUBATION.

We still pursue the description of M. Gehin's plans, for their simplicity; and we have seen that in artificial fecundation Nature has been imitated, where the fish voids its eggs by passing over and pressing its belly against smooth stones. This natural method being imitated by the hand of the operator, all the eggs are evacuated, without the loss of a single one.

In artificial incubation M. Gehin takes a round box, in the form of a warming-pan, except that the bottom rises a little in the inside in order to make it remain more firm in the position in which it may be placed. It is made of zinc, to prevent rust; its size is twenty centimetres in diameter and seven centimetres in depth; the lid four centimetres in height, on hinges with a catch. The box is pierced on every side, so that the water can freely flow through it over the gravel. These holes are a millimetre in diameter, and should be very carefully and smoothly made with a punch, in such a manner as not to wound the little fish attempting to escape through them.

The bottom of the box is covered with a bed of fine gravel, and on this are placed the fecundated eggs. Each box should contain one brood of eggs. The box is then closed, a hole is dug for it in the gravelly bottom of a running stream of fresh water in which it is placed, and gravel is strewed over it.

It is necessary to take these precautions in order that the water flowing through the gravel may be purged of its impurities before it enters the box, and not deposit mud or slime upon the eggs, and retard and prevent altogether the hatching, as Gehin and Remy observed was the case when such precautionary measures were omitted.

The box so placed is left for a month or two. M. Gehin could not determine the exact time of the process of incubation, as it varied with the quality of the water. "This question," says M. Godevier, "is now occupying the attention of scientific men, and from their researches we shall have the exact results. As incubation goes on and hatching time approaches, in order to determine when it will take place, and not to their injury retain the little fish too long prisoners, the boxes should be frequently inspected. When incubation is finished, and the little fish begin to move, they must still be kept enclosed from eight to fifteen days, according as their numbers are small or great; then they may be set at liberty in the quietest part of the stream, care being taken that the quality of the water is the same as that which has flowed through the boxes, for a change to water of more or less freshness or clearness will have a sensible influence on their frail existence.

"A wide field was here, of course, open to any one who chose to enter upon it: for example, it was very interesting to ascertain the results of different modes of treatment by placing similarly, either confined in large boxes or at liberty in running brooks, equal numbers of young fish, and supplying one set with thickened blood, ground liver, and other food, and leaving the other set to find such food as Nature affords, to note the relative increase. Experiments, likewise, might be made with boxes having larger holes than those before described—large enough for the escape of the young fish as soon after hatching as they might seek their liberty, which mode might do away with the necessity of watching the process of hatching, with the view to opening the boxes soon after.

"In some sections of the country, where many crops have been gathered from the same plot of ground, it becomes in a degree exhausted, and, whether to improve it for the same or prepare it for another kind of crop, it is usual to overflow it, converting it into a fish pond, and stocking it with carp and tench. After three or four years the water is drawn off, the fish taken and sold, and the land cultivated. A few years having elapsed, it is again overflowed, but need not again be stocked with fish, as they now appear, as it were, spontaneously. We have the evidence of numerous observers as to this fact, and among others the inhabitants of a commune near Grenoble. They state that there is a little lake on the side of a hill in the commune of Jarrie, not far distant from their town, which is well stocked with carp and tench. Sometimes the lake dries up, and the ground is then cultivated with hemp, and yields abundantly; and again it is filled with water, and carp and tench appear in great quantities.

"The river Drac has a wide bed, and the current at times reaches new channels or re-takes old ones which have dried up; in the pools of these old channels soon appear quantities of trout, whose size shows their age to date from the period of the water's return. This fact is vouched for by the fishermen of that river. The inference is clear, that the fecundated eggs have been left in the bed of the channel at the time it dried up, and so remained until the returning waters have united all the necessary elements of incubation, which has then taken place, and soon after the eggs have been hatched."

Founded on these facts M. Gehin adopted the following mode of preserving and transporting fecundated eggs:—

He takes one of the boxes already described, and covers the bottom with a bed of very fine sand; he covers this with a layer of gravel or pebbles, varying in size from a pea to a hazel-nut, and upon the gravel he spreads a layer of fecundated eggs; these again are covered with sand, and then another layer of gravel, and then one of eggs, and so on, until the box is filled. He takes great care beforehand to wash the sand and gravel so as to free it entirely from every particle of mud or slime.

When the box is full he dips it in water, so that its contents shall be thereby more closely packed together; and being thereafter exposed to the air it can be sent anywhere without altering the condition of the eggs. On the receipt of the box the contents are taken out and placed in five or six other boxes, each containing the spawn of one female; and these are placed in the gravelly bed of a stream, according to the directions before given as to artificial incubation.

If any of the eggs have a different appearance from that before described, as fitting them for incubation, they must be thrown away; and the cleaner the eggs are the better will be the success of the experiment. The sterile and spoiled eggs become white and opaque, like the white of a hen's egg boiled, and if broken yield a milky fluid.

M. Gehin meets a difficulty in a characteristic way. Trout fishing is prohibited in France during spawn time—that is, during November and December—because the fish, coming then together in shoals, can so easily be taken and the work of reproduction prevented. But fishermen, stimulated by large profits and lessened toil, brave the law, and destroy in the germ millions on millions of fish. To these fishermen he gives this advice: they should take with them a little pot made of zinc, say five inches in diameter and six inches deep; it should be filled one-third full of water, and a piece of wood the size of the pot may cover the water to prevent its splashing out as the pot is carried from one place to another by the fishermen while at their work. When they take a female fish they should put her eggs in this pot, and in like manner put into it the milt from the male fish. M. Gehin thinks it unimportant whether the milt or the eggs be first placed in the pot; that will depend on whether the female or male is first caught. When they have done fishing they should dig a hole in the bed of the current near where they have been fishing, and cover the bottom with fine gravel; into it they should pour the eggs, which, when fecundated, will drop to the bottom among the gravel like little shot; the hole should then be filled up with little stones and covered with gravel, and incubation will go on, and in due time the eggs will be hatched. "By this means," adds M. Gehin, "the fishermen, by reaping all the advantage of their illegal trade, will not be, in fact, doing any injury to the process of reproduction."

It has been observed that fish are with difficulty acclimatised on being taken from one stream to another; often they die, almost always they become sterile. But eggs so transported are easily incubated and hatched, and produce fine fish. Indeed, it has been remarked that, except in a running stream, other fish than carp and tench become barren. When fish are caught for the purpose of taking from them the eggs, and are found to be in an unfit state to be operated upon, from not having gone their full time, they should be kept in a reservoir until the proper time, and then relieved of their eggs and set at liberty again. Otherwise they will die in the reservoir, as they will not, while in that manner kept prisoners, spawn naturally, but will retain their eggs and perish. When eggs are preserved in water, it must be frequently renewed, or aquatic plants be placed in it: these plants preserve the eggs in an unchanged condition.

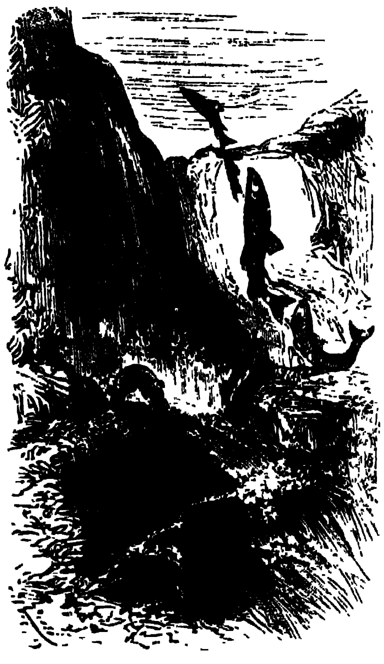

Fig. 12.—SALMON LEAP—SHOWING HOW THE LEAP OF THE FISH IS EFFECTED.

As an evidence that there is something wrong in the exercise of those experiments which are so continually announced as failures either partial or complete, we quote from a French work upon the subject of breeding fish, which says: "Like all other great discoveries, now that we have it, this seems the simplest in the world. How, we ask ourselves, was it possible for any one to eat fish-roe without thinking of the innumerable fish thus destroyed in the germ, and what would that thought lead to but the search for a mode of preventing such wholesale slaughter and the easy discovery of such a mode? Yet it took six thousand years to find the right means to solve readily and practically the difficulty; and we now *have the solution in so simple a form that even the children of fishermen practise it as easily as they would tend a flock of sheep.*"

Next was demonstrated the possibility of creating at will mixed breeds, by mixing the spawn and milt of two different species; and the author shows the possibility of hatching artificially, near ponds containing unproductive species, the eggs of these very species, and of stocking these ponds with young fish from these eggs. Every part, indeed, of his research is characterised by such exactitude and practical good sense, that all fundamental questions are resolved; and this new discovery had hardly appeared in the domain of science when it was transferred to that of industry.

In 1841 the late Mr. Boccius, C.E., to whose zeal and observation we can from a long acquaintance personally testify, carried to still greater lengths practical results of such experiments. He, like those who preceded him, made use of artificial fecundation for stocking the streams of Mr. Drummond, in the Colne near Uxbridge, and he estimated the number of trout he produced and brought up there at 120,000. We, however, who continuously fished this water, never found any appreciable increase of sport, nor did we notice any greater number of trout after a year or so, in the pools or in the shallows. But these fish, as they are migratory, may have worked either up or down the stream, and thus benefited neighbouring waters more congenial to their nature. We possess several MSS. of Mr. Boccius, which tend to show the earnestness of purpose by which he was actuated, and could have wished that the results had been more in accordance with his exertions, and from his very failures there is much to be learned. Our own opinion is that there has been some faulty observations here. He says one part of his system is to breed none but the superior classes and qualities of fish, the finest costing no more trouble to protect and feed than the inferior kinds.

Owners of waters should be cautious against grasping at too much, either in weight or numbers. Large fish devour far more in proportion than smaller ones; and too great a number of a lesser size eat up the food, and the whole stock becomes lank and lean. Again, the larger fish hunt and harass their weaker brethren, and hinder them from obtaining food. On this account, where many exist the fishery is not upon a fair footing, and certainly not in a progressive or prosperous state. It were better that large fish, after a certain age, should be taken for food, or else removed for productive purposes elsewhere. Fish which can obtain their food in an easy and peaceable way will increase far more rapidly than those which have to travel for it. This explains the seeming contradiction that trout in some waters are only in condition two or three months in the year. The simple answer is, that eight months of the twelve they are, from scarcity of food, so starved that they are compelled to feed upon the smaller sort of their own fraternity. These, being swift of movement, become difficult to take; so that the fish are more like skeletons, or heads and tails of trout, than fish worth taking, and do not get into condition till the fly season comes round again.

Those who have permission from owners to take eggs from trout or salmon, cannot be too careful in handling the fish; above all, they should never touch the gill or gill-covers so as to injure them, for if a fish bleeds from the gills he is sure to die. "He must not be squeezed, but you must hold him gently round the small of the tail (the 'wrist' I call it) with the left hand, and keep his head loosely in the hollow of the right hand. Sometimes the eggs are white, sometimes amber colour. Do not throw the fish rudely back that are not ready, but carry them to the water and slip them gently in—like one slips a ferret into a rat-hole. Female fish, if faint, should be supported, head up stream, in the hand, until they swim away of their own accord. If you are in doubt of the eggs being ripe, take one of them in your mouth, and bite at it; if you find it soft and can catch it easily between the teeth, and it cracks, you may be quite certain that the egg is not ripe; if, however, on the contrary, you have a difficulty of catching the egg between the teeth, and it slips away from between them, feeling like a ball of glass, and you have a difficulty to crack it, the egg is perfectly ripe. When the eye of the young fish is visible in the egg, the external transparent horn-like shell of the egg is quite hard, tough, and very elastic; for if you drop an egg in this condition, it will rebound like an india-rubber ball. This is a wonderful provision of Nature to preserve the young fish from the superincumbent weight of the gravel."

PRINCIPLES OF DESIGN.—XXVII.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

SILVERSMITHS' WORK (*continued*).

Having chosen a form for a vessel, the next question with which we have to deal is, will it require a handle and spout? It is curious that while the position of a spout and handle in relation to a vessel is governed by a simple natural law, we yet rarely find them placed as they should be. This is the more curious, as a vessel may become practically of immense weight, owing to the handle being misplaced.

A pound weight is easily lifted, but when applied to the shorter end of the steelyard it will balance a hundredweight. If this principle is applied to a tea-pot which actually weighs but little, it may yet be very heavy to lift. In nineteen cases out of twenty, handles are so placed on tea-pots and similar vessels that they are in use lifted only by a force capable of raising two or three such vessels, if the principle of the steelyard was not acting against the person who uses the vessel. Take our ordinary form of tea-pot, and see how far the centre of the weight (the centre of gravity) is from the handle in a horizontal direction, and you will be able to judge of the leverage acting disadvantageously to the person who may pour tea from such a pot. Now if the part held is to the right or left of a right line passing through the centre of gravity of any vessel, there is leverage acting to the disadvantage of the person desiring to pour from that vessel, and this increases just as the point held is removed from the central line spoken of.

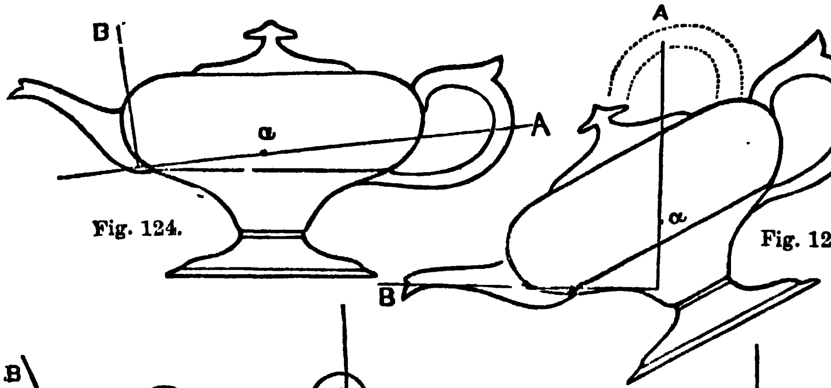

Fig. 124.
Fig. 125.

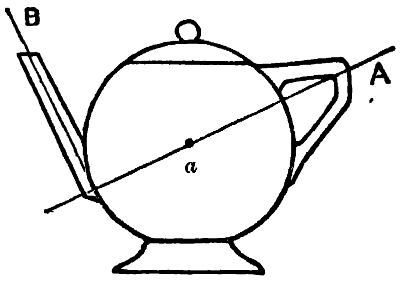

Fig. 129.

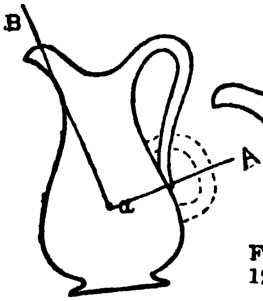

Fig. 133.

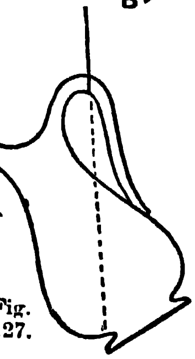
Fig. 127.

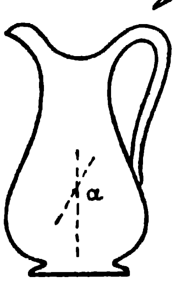

Fig. 128.

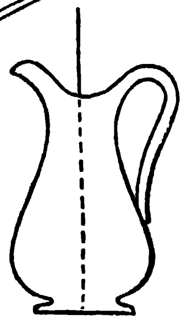
Fig. 126.

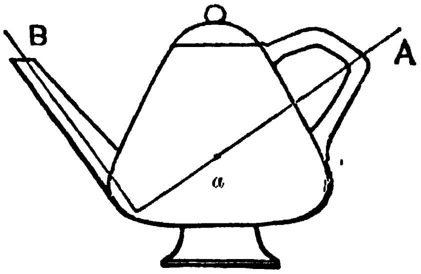

Fig. 130.

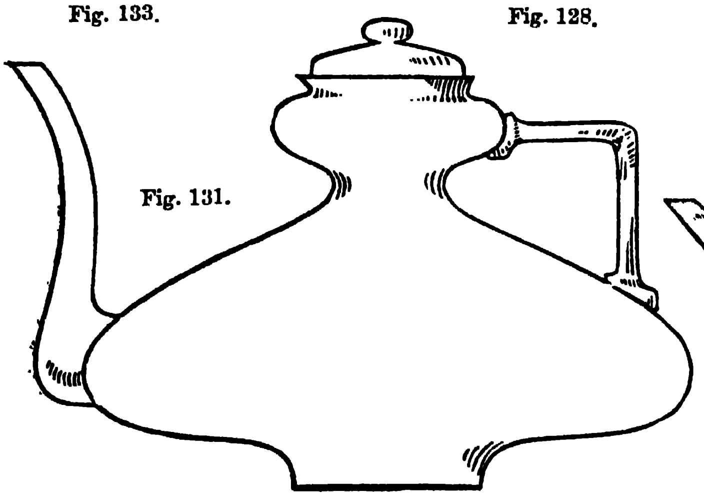
Fig. 131.

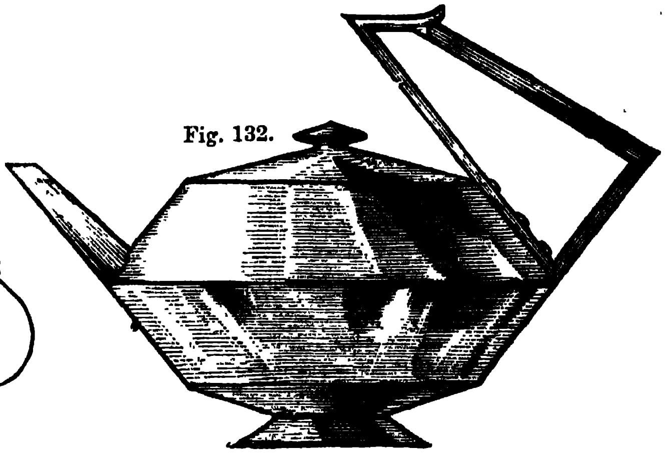
Fig. 132.

Fig. 124 would pour when in the position shown in Fig. 125, but see how far the hand that holds it would be to the right of the centre of gravity, which distance is of great disadvantage, as it causes the vessel to appear much heavier than it actually is, and requires a much greater expenditure of force in order to put it to its use than is necessary were it properly formed.

The law governing the application of handle and spout to vessels is this, and the same principle applies whether the vessel be formed of metal, glass, or earthenware:—Find the centre of gravity of the vessel, which can easily be done by letting a vertical line drop over it when placed in two different positions, as in Figs. 126, 127. and where the two vertical lines intersect, as in *a* in Fig. 128, is the centre of gravity. The position of the handle being fixed on, draw a line through the centre of the handle, and continue it through the centre of gravity of the vessel. The spout must now be at right angles to this line. If this be the case the vessel will pour freely, while the handle is just hung upon the thumb or finger of the person desiring to pour from it, as may be seen from Figs. 129, 130, in which the straight line A, passing through the centre of gravity *a*, is at right angles, as it should be, with the straight line passing through the spout.

This law, if obeyed, will always enable liquid to be poured from a vessel without its appearing heavier than it actually is, but it will be seen that the shape of the vessel must be considered so that the spout and handle can bear this relation to each other, as in Figs. 131, 132. Some shapes will not admit of it, so they must be avoided, as may be seen by examining Figs. 124, 125, which show a tea-pot of faulty shape in this respect.

A consideration of this law shows us that the handles of jugs, those formed of silver, of glass, and of earthenware alike, usually have the handles too high; but in this respect things are much better than they were a few years back. Now we somewhat frequently see a jug with the handle in the right place, while some years back we never did. Silver jugs are now the most generally faulty in this respect, and such mistakes as the wrong placing of the handle or spout of a vessel result only from ignorance, for no man knowing the law would violate it (Fig. 133).

It is unnecessary that I say more respecting shape and the general construction of silver and gold vessels, except to remark that if figures or other ornaments are beaten up on the surface of a vase, they must not destroy or mar its general contour.

Iron is not used with us as it should be. Not only is the effect produced when it is inlaid with silver and other metals excellent, but by this mode of work our art creations are greatly preserved, for the iron is valueless, and the labour of removing the small quantity of precious metal inlaid would be so great as to render the gain inadequate remuneration for the time consumed in collecting it.

M. Christophle, of Paris, and also M. Barbedien in a lesser degree, have commenced to inlay copper vessels with silver, and some of their works are very beautiful; and the Japanese have from an early time inlaid silver in bronze. This inlaying of silver into copper is a step in the right direction, and should be encouraged by all lovers of art. The Indians not only inlay silver in iron, but also gold in silver; and the firmness and intricacy of some specimens of this inlaying are truly marvellous.

By the process of enamelling, colour can be applied to metal, and of all arts this art of enamelling produces works which are most lovely; at least, if the best works of enamel do not surpass those produced by any other manufacture, they are, at least, equal with the works of the highest excellence. Transparent enamels are in some cases very beautiful, but they do not generally compare with the opaque enamels, such as were largely used by the Chinese about a hundred and fifty years back, and by the Japanese, or those now so skilfully applied by Barbedien, the Algerian Onyx Company, and Christophle, all of Paris.

Chinese *claisonné* enamel vases may be seen at the South Kensington Museum, and here you may also find one or two small pieces of Japanese enamel, as well as one or two grand specimens by Barbedien, of Paris.

The Chinese enamels have most frequently a light blue (sort of turquoise) ground, but they occur with both red, white, green, and yellow grounds; while the ornament is of mixed colours, but generally with light yellow-green, deeper blue-green, or dark blue prevailing in it.

The Japanese enamels have a lower tone of colour-effect than the Chinese, and the work is finer and the colours more mingled, while the modern French enamels are full in colour, and are yet rich and subdued in general effect—some of them, indeed, are most beautiful works.

Elkingtons, of Birmingham and London, have also produced some beautiful things in this way, but not in the quantities that Barbedien has. I most strongly advise the art-student to study these works in enamel.

Niello work is a form of enrichment applied to metal not in general use; it is a difficult process. Silver snuff-boxes and pendants for watch-chains with a niello pattern upon them are not uncommon in Belgium and Russia, the niello pattern appearing as dark lead-pencil work upon the silver. Some niello work is very quiet and beautiful, but much need not be said respecting it.

Jewels may be inserted in metal, but if this is done they should be somewhat sparingly used, even in the most costly of works, for if they are abundant they produce mere glitter, and the aim of the ornamentist must in all cases be the production of repose.

FARMING AND FARMING ECONOMY.—IX.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

BARLEY—OATS—RYE.

LAWSON describes twenty kinds of barley, all referable to the following four species: *Hordeum distichon*, two-rowed barley, comprising ten varieties; *H. vulgare*, four-rowed barley, represented by eight varieties; *H. hexastichon*, or six-rowed barley; and *H. zeocriton*, fan, spratt, or battledore barley—the two last having each one form only. The finer sorts all belong to *distichon*, while *vulgare* and *hexastichon* are found as hardy, coarse cereals, in northern latitudes or high exposed situations where wheat cannot be depended upon.

Common Two-rowed or English Barley.—Ears three to four inches long by one-third of an inch broad; containing 28 to 30 grains, not closely set on the rachis; awns extending about the length of the spike beyond its point.

Chevalier Barley.—Ears resemble the last, but contain two to four more grains; grain rounder, plumper, and superior to last; eight to ten days later in ripening; weight from 56½ to 58 lb. per bushel.

Annat barley is the produce of two selected ears picked from a field of Flaw Craig Farm, Carse of Gowrie, in 1830, and subsequently propagated by Mr. Gorrie, of Annat Garden. Grain rounder, plumper, and heavier than the preceding varieties.

Lawson also describes *Dunlop, Stains, Golden or Italian, Chancellor, and Royston* barleys, and black and naked varieties, in which last the grain may be separated from the chaff.

The four-rowed barleys include common *Bear, Bere or Barley-big.* This variety has an ear 2½ inches long, containing about 60 grains; grains pointed, or tapering to both ends; awns about 3½ inches long; cultivated chiefly in the Highlands of Scotland, and in the Lowlands on exposed, inferior soils.

White-rowed winter barley has thicker and rather longer ears, grain larger, skin thicker, and coarser than the last: sown in autumn, and is earlier than any spring variety.

There are also Square, African, Tangier or Morocco, Bengal, a black, and two naked varieties of four-rowed barley.

Six-rowed white winter or Pomeranian barley has six equidistant and distinct rows, the lower grains nearly at right angles with the rachis, awns in consequence much spread. It is the coarsest kind of barley cultivated, but is hardy and prolific.

Putney, fan, spratt, or battledore barley (*H. zeocriton*) is characterised by a short ear, very broad at the base; grains standing out from the rachis as in the last; awns spread much to both sides; very much resembling *H. hexastichon* except in the numbers of rows. Not widely cultivated.

PLACE IN ROTATION.

Barley occupies a leading position upon all light and medium soils. It usually follows a root-crop, consumed upon the land by sheep. A rich condition of soil, induced by a liberal use of purchased food, is inconsistent with the production of the finest samples of barley. Accordingly, some take this crop after wheat, so as to ensure a higher quality of produce.

Turnips being required for folding purposes up to May, the sowing of barley is often delayed to that time. When the weather is genial, such late sown barley may give a large return, but too often the dry character of this part of the year causes a rough, cloddy condition of soil, unfavourable to the development of barley. Hence in such cases it has been recommended to take white turnips after such late swedes, or a second root-crop, which will be fed off in the autumn in time to be followed with wheat, afterwards to be succeeded by barley. This plan, which gives two root-crops and two grain-crops in four years, avoids risk, and ensures better malting barley.

PREPARATION OF GROUND, ETC.

The sheep-fold may be looked upon as the leading feature in all barley-growing districts. As soon as the sheep have cleared a sufficient space for tillage operations, the land should be ploughed about three inches deep. This ought to be done as early as possible, so as to obtain the ameliorating influences of frost upon the land. The best conditions of soil are a fine top and a firm bottom, and this is best obtained by early, shallow ploughing, followed by harrowing. Another advantage of a fine surface is that weeds spring rapidly, and are destroyed by harrowing at sowing time; whereas, if ploughing and sowing proceed together, the charlock, poppies, and other seedlings appear with the young barley and prove troublesome. The plough is occasionally relinquished for the cultivator in preparing land for barley with the view of securing the condition of soil and subsoil already indicated. Barley may be sown as early as the middle of February and as late as the latter part of May. March and April are both good months, but generally the largest crops and longest straw are obtained after early sowing. The seed is deposited by the drill in rows 8 or 9 inches apart, and at the rate of 2½ to 3 bushels per acre. The seed is not "pickled" previously to sowing, as in the case of wheat. No after cultivation except rolling is required.

HARVEST.

Barley being required for malting is allowed to ripen more thoroughly than wheat. If it were principally used for grinding into flour, the same rule of early cutting would apply to it as is found so desirable in the case of wheat; but uniformity of germination or sprouting is not obtained unless the grain is ripe when it is cut, hence the difference in practice. Barley is cut by reaping-machines or scythes, when the heads are bent over and the grains are hard. It is very often carted loose or untied in the south of England, but in the north and in Scotland it is bound into sheaves. More care is required in harvesting and preparing barley for market than wheat. The malt-tax, which is looked upon by most farmers as one of their greatest grievances, tends to exaggerate the difference in price between the best and second-best samples of barley. The same tax has to be paid on both; therefore, it is advisable to buy first-rate barley, and pay the tax upon it, rather than inferior samples with the same burden. Hence a great demand for top samples, and comparative neglect of those of second quality. Barley may be "put together" in a rick too early, and become bitter and high-coloured from heating; it may become dry (flinty) by too long exposure to the sun; it may be injured by rain; or it may suffer from imperfect threshing and dressing machinery. Any of these causes may result in a considerable reduction of price; and much careful management is required in order to bring a "well got up" good sample into the market.

Barley requires to be "hummelled," or deprived of its awns, after it has been threshed. This is effected by a special apparatus attached to the threshing machine, which may be described as a long cylindrical box placed across the machine, one end being higher than the other. In the centre is a spindle turning rapidly by means of a strap and sheaf. Upon this spindle a number of radiating, blunt knives are spirally attached from one end to the other, and as these revolve they cut off the awns of the barley, which, entering at the higher end, gradually passes through the "hummeller" into a winnowing machine, where the awns are blown away. Barley may be deficiently hummelled, in which case it will weigh badly in the bushel, and be displeasing to the eye; or it may be too closely dressed, and thus injured for malting. A bruised or broken corn will become mouldy upon its broken surface during the malting process.

OATS.

All our cultivated oats belong to two species, *Avena sativa* and *A. Orientalis*. Besides these, there are *A. nuda* and *A. brevis*, neither of which are grown in this country. The first two species comprise upwards of thirty-two varieties, of which thirty belong to *sativa*. The two sorts of *Orientalis* are known as white and black Tartarian oats, and are characterised by great length of straw, a long secundate, or one-sided panicle, awned grains, and thick, not very well filled husk. They are light in the bushel (39 lb.), but yield largely, and furnish good food for work-horses. Both are suitable for poor, exposed soils, where the finer classes of oats do not succeed.

The varieties of *A. sativa* are generally well marked. They are conveniently divided into early and late, and among the former the following are the best known:—

The *potato oat*, discovered in a potato-field in Cumberland, in 1788. Panicle spreading on every side, but rather compact and regular; straw inclined to be short; grain white, short, plump, and weighing as much as 46 lb. per bushel; adapted for good land.

The *Hopetown oat*, raised by Mr. Patrick Sherriff, of Mungoswells, East Lothian; ripens a few days earlier than the potato oat; not so liable to be blown out; straw longer and stronger; panicle more spreading; grain rather more awned and a shade browner in colour; and distinguished by a small reddish mark in the centre of the front of the grain.

The *Sherriff oat* is another of Mr. Sherriff's varieties; its chief point of excellence is its earliness. It is thick in the skin, small in the grain, and light in the bushel. This variety is known in Kelso market by the *sobriquet* "make him rich."

The *Sandy oat* was found by A. Thomson, herd-boy to Mr. Pirie. It is strong in the straw, and liable to blow out. The straw assumes a fine golden colour some days before the crop is fit to cut; the grain is small, and resembles the potato oat. It is useful for soft, peaty soils. The *early Angus* is nearly as early as the potato oat, and less liable to be blown out.

The *Poland oat* much resembles an inferior sample of potato oats. The *Canadian oat* is very similar to the above. Besides these, the Kildrummy, Barbachlaw, Friesland, Birley, and Cumberland early are all well-known varieties. The Dun or winter oat is very hardy, and may be sown in the autumn. It is characterised by a tawny-coloured grain, and is very early in coming to maturity. The common Dun oat is a rather late variety adapted for poor elevated soils.

CULTIVATION OF OATS.

In the southern, eastern, and western counties oats follow roots fed upon the land; and in the north of England and Scotland they are usually taken after one or two years' grass (see Northumberland Rotation, Vol. II., page 262). Oats are hardy, and grow to greater perfection in the north than in the south. The large choice of varieties furnish suitable kinds for every class of soil, from the rich land where potato oats thrive, to the rough fells on which the Tartarian oat furnishes an abundant supply of straw and grain. The preparation of root-land for oats is similar to that for barley. When the crop follows lea, the land is ploughed about January, allowed to lie until a stale furrow is secured, drilled or sown broadcast, and well harrowed. March is the best month for sowing oats, and from 2½ to 3 bushels of seed will ordinarily be sufficient. Oats are as a rule sown more thickly than either wheat or barley. Rolling is all the after-cultivation they receive, unless we include under this head a top-dressing of guano or some ammoniacal salt.

No crop derives more benefit from change of seed than oats, and it has been shown that there is some advantage in mixing two varieties together for seed. Mr. Finnie, of Swanstown, obtained the following results per acre from different kinds of oats sown separately, and mixed upon equal portions of land:—

Potato oats . . .	bushels	74	Dun oats . . .	bushels	76
Hopetown . . .	„	65	Sandy oat (unchanged seed)		56
Early Angus . .	„	77	Sandy oat (changed seed)	„	61
Kildrummy . . .	„	77			

When mixtures of two varieties were employed—

Hopetown and Kildrummy gave .	85	bushels per acre.
„ and Sandy	80	„ „ „
„ and Early Angus . .	76	„ „ „
Potato and Early Angus . . .	66	„ „ „
„ and Sandy	66	„ „ „

Oats, of all cereals, should be cut early—(1) because they are apt to blow out; (2) because oat-straw is a valuable fodder, especially when cut soon. They are cut with the reaping-machine, tied up, stacked, and carried as in wheat harvesting; they require more time to dry than other cereals. In the North farmers "guitan" oats, or set up individual sheaves tied loosely near the head, and with the butt-end spread out to give support. This allows a free circulation of air through the gaitans, and when sufficiently dry they are tied up into ordinary sheaves and carried.

RYE.

Secale cereale is represented by common rye and St. John's Day rye. Both are used extensively as forage crops (see Vol. III., p. 27). They are also, to a limited extent, grown for seed. Rye is suitable for light sandy soils, and in the north of England it is sometimes mixed with wheat, and grown under the name of "maslin." This mixed crop occupies soils which are considered too light for wheat; it ripens uniformly, and is sold for a price but little below that of ordinary wheat samples. The St. John's Day or Midsummer rye differs from common rye in being later, and in producing longer straw and ears, and more foliage.

The cost of producing the three foregoing crops may be approximately stated as follows:—

	s.	d.		s.	d.		s.	d.		s.	d.
Ploughing	8	0	Drilling .	1	10	Rolling .	0	9	Threshing	8	0
Harrowing	2	0	Seed . .	12	0	Harvesting	12	0	Winnowing	5	0

Winnowing includes cost of marketing. The whole amounts to £2 9s. 7d., to which £1 15s. may be added for rent, rates, etc., making a total of £4 4s. 7d.

An average crop of barley on fair land, well farmed, will yield from 35 to 40 bushels of grain, and from 60 to 65 bushels is a heavy crop. Oats yield very differently, according to variety. Tartarian oats will produce 50 to 60 bushels, which is a moderate crop, up to above 100 bushels. An average crop of potato oats ranges from 45 to 50 bushels, and a maximum crop 80 bushels per acre.

MINING AND QUARRYING.—XVII.

BY GEORGE GLADSTONE, F.C.S.

TIN (*continued*).

SMELTING—REFINING—PROPERTIES OF TIN—USEFUL APPLICATIONS—BRONZE: ITS PREPARATION AND USES—PEWTER—SOLDER—USE OF TIN IN DYEING.

THE whole of the tin ore raised in Cornwall and Devonshire is smelted within those counties, in compliance with an ancient privilege granted some centuries ago.

The process is a comparatively simple one, the metal being easily reduced from its oxide; but it has to undergo subsequent operations before it attains to its purest condition. The smelting is performed in a reverberatory furnace, the ground-plan of which is shown in Fig. 10, where two basins, A A, for the reception of the molten metal, are seen at the side of the furnace. The bridge is at B, the charge is introduced at C, and it is worked by the furnace-man through the opening at D. The bridge and sole are hollow, to allow the air to circulate freely under them for the sake of modifying the heat to which they are exposed.

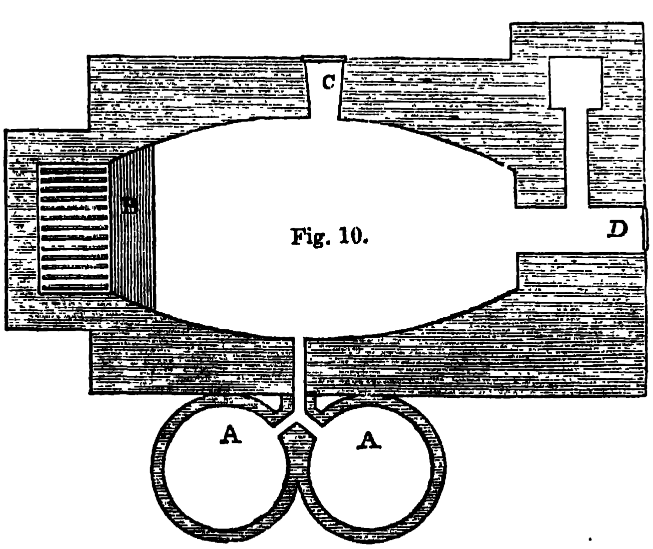

Fig. 10.

A charge consists of about 20 cwt. of ore, which contains on an average from 62½ to 65 per cent. of metallic tin: this is mixed with about one-seventh of its weight of powdered culm, and a little slaked lime. Before being introduced into the furnace they are intimately mixed together, and slightly moistened with water, because if they were passed in a dry state, such a fine powder would be blown up the chimney by the strength of the draught. The door is then shut and luted closely, and the temperature of the furnace is gradually raised, for six or eight hours, after which the door at D is opened, and the molten mass is stirred to facilitate the separation of the scoriæ from the metal. As soon as the reduction appears to be complete, the scoriæ are raked out through the same aperture. That which is uppermost is thrown away as valueless; the next batch usually contains about 5 per cent. of tin intermixed with it, and is sent to the stamps that the metal may be separated by the means previously described; the scoria which still remains contains so much tin as to be worth smelting again. All this being removed as far as possible at this stage, the channel leading to the basins, A A, is opened, and the tin flows into them, the floor of the hearth being made to slope slightly downwards for the purpose. Any scoria remaining mixed with the metal rises to the surface, as it is of less specific gravity, and is then removed; the metal is lifted out with ladles and poured into moulds to cool. The scoria of the second class, after being stamped and washed, is added to that taken out afterwards, and this mixture is called "prillion." It is smelted by itself, and makes an inferior metal.

The tin thus prepared is not, however, pure enough for use, and has therefore to be refined. The furnace used in this operation is similar to that above described, except that it has only one basin instead of two. This is usually about 4 feet in diameter, by 2 feet 8 inches in depth, and is made of iron with a fire-place underneath it, as it is necessary to keep the metal in the basin liquid for some time. The ingots of tin from the smelting-house are piled up in the refining furnace near the bridge, and as they melt the liquid metal trickles down, and passes out into the basin, fresh ingots being inserted as the first batch melts away, until there is sufficient to fill the basin. The impurities, principally consisting of iron, which do not melt so readily as tin, remain behind on the hearth of the furnace.

Billets of green wood are now forced into the molten tin, and kept there for about three hours. The heat causes the evolution of gas from the green wood, which, in escaping, produces a brisk ebullition of the metal, and a quantity of froth, which collects on the surface. This froth consists, for the most part, of the imperfectly reduced oxides, and is therefore skimmed off from time to time, and returned to the furnace. When the boiling has continued for the time above named, the billets are withdrawn, and the metal is allowed to settle. The purest metal will now be the lightest, and will therefore occupy the upper portion of the basin; this is ladled out and poured into ingot moulds to cool. The ingots first made will consist of the best quality, and are called refined tin; those which succeed, and which are sufficiently pure for ordinary purposes, are sold under the name of block tin. What remains at the bottom of the basin will contain too many impurities to yield a merchantable article, and has, therefore, to undergo further treatment.

The residues which are left on the hearth of the refining furnace are subsequently melted by increasing the temperature, and the alloy is run out into another basin, where, after awhile, it separates into two portions; the more fusible, consisting mainly of tin, is poured into moulds, and is refined a second time; the remainder, which adheres to the sides and bottom of the basin, is rejected as not worth further treatment.

The quantity of refined metal produced is about 9 per cent. short of what it should be theoretically; which, considering the high value of the article, is a serious item; it is a matter worthy of study, whether some of this loss cannot be prevented, or subsequently recovered.

Pure tin is a brilliant white metal, which is only very slightly acted upon by the air or by water, at an ordinary temperature, so that it will retain its brilliancy unimpaired for a long time. It is too soft, however, to be used alone in the manufacture of utensils, as in order to secure the necessary strength such a thickness of the metal would be required as to seriously enhance the cost; for such purposes it has, therefore, a foundation of some inferior metal, such as iron, the tin merely forming an outer coating; or it is alloyed with a cheaper metal, such as lead, constituting pewter. In respect of hardness, tin occupies an intermediate place between lead and pure gold; in conductivity for heat it is superior to lead, but is inferior to zinc, iron, copper, or the precious metals. Its specific gravity is 7·29. It melts at a comparatively low temperature, 230° Centigrade, equal to 446° Fahrenheit. When exposed to a red heat it absorbs oxygen from the air with avidity, forming the peroxide of tin, which is a whitish-coloured powder. The pure metal is very malleable, so that it can be beaten out into foil of only $\frac{1}{1000}$th of an inch in thickness, but it is not very tenacious. It is of use in the arts, both in a state of solution and as an oxide; and it plays the part also of an acid, forming valuable compounds with the alkaline metals.

In considering the various appliances of tin, we will first take the principal alloys into which it enters, their preparation and characteristics.

Bronze is an alloy of copper and tin. Historically it is probably the oldest of all compound metals, and was perhaps used at almost as early a period as any pure metal. The collections of Egyptian, Greek, and Roman antiquities and coins in the British Museum furnish innumerable specimens of this alloy. As modern examples of its use we may mention cannon (incorrectly called "brass guns"), bells and gongs, our new (again often mis-called "copper") coinage, the statues and lions in Trafalgar Square, etc. etc. In character it differs widely from either of its constituents. The product is hard, tenacious, and slow to tarnish on exposure to the air. In respect of fusibility it occupies an intermediate place between copper and tin; and the same applies to its density, though this is somewhat greater than the mean of its components. This anomaly increases with the proportion of tin employed; thus an alloy consisting of equal parts of the two metals would theoretically have a specific gravity of 8·09, but it is found by experiment to amount to 8·79.

In making bronze castings the proportions of the ingredients are varied according to the nature of the work in hand. For coins and medals about 10 per cent. of tin is used, a small quantity of zinc being also sometimes added. The object is to make a sufficiently hard alloy, so as to withstand a considerable amount of wearing, and yet one which will receive a sharp and good impression under the die.

A compound largely used by engineers consists of copper, tin, and zinc, the tin being generally in larger proportions than above named. 18 per cent. of tin to 2 per cent. of zinc and 80 per cent. of copper produces a very hard metal: by slightly increasing the copper at the expense of the tin, a more malleable compound will be obtained. A portion of the zinc may also be replaced by lead. Another quality of engineers' metal, which is advantageously employed in some parts of machinery, consists of 87 per cent. of copper, 12 per cent. of tin, and 1 per cent. of antimony.

Brass guns, as they are commonly called, are usually made of an alloy containing about 89 per cent. of copper and 11 per cent. of tin. In view of the great strain to which the metal is necessarily subjected, much care has to be taken in the casting of them—firstly, as to the purity of the materials, and secondly, as to the homogeneity of the alloy. The smallest admixture of sulphur or arsenic will tend to make it brittle, and therefore liable to burst when being fired off; a very small admixture of lead will make too soft a metal, and one liable to be rapidly acted upon by the heat generated in the explosion of the gunpowder. In making a bronze casting of the size of a cannon, it is a matter of no little difficulty to produce a similar alloy throughout, as the tin is lighter than the copper and has a tendency to separate more or less from it; so that it not unfrequently happens that the upper part of a large casting will contain a greater relative proportion of tin than the lower part. This will also affect the strength of the gun, and is therefore by all possible means to be avoided. The metal is melted in reverberatory furnaces, so arranged that the flame shall not produce an oxidising effect upon the charge; and the furnace is raised to a high temperature. When the metals are quite liquefied, the whole is well stirred up with a long wooden pole, which produces an ebullition, as in the refining of tin, and causes an intimate mixture of the two ingredients. When the charge has been sufficiently poled, the furnace being still kept up at its full heat, the plug is withdrawn, and the molten mass runs down the channel into the moulds prepared to receive it.

In casting statues and the like, it is not so absolutely important to ensure the purity of the materials and the thoroughness of their mixture, as the weather test is the principal one which they have to stand. Even in this case, however, attention should be paid to these points, as copper suffers rapid waste by exposure, and the good effect would be lost if one part of the figure were to show more oxidation than another. Many old statues will furnish proofs of bad melting, some portions being honeycombed and eaten away by weathering, while others are comparatively fresh and sharp. The now prostrate column of the Place Vendôme at Paris is a notorious example of the imperfect mixture of the tin and copper, the relative proportions in some segments being widely different from what they are in others. Though bronze, whatever the proportions of the ingredients, is always more fusible than copper, it is not by any means easy to make a very large casting which shall be satisfactory in all respects; and the plan is therefore often adopted of making the figure in separate segments, and afterwards uniting them by means of a hard solder, such as will be produced by a mixture of three parts of zinc to four of copper. The colossal lions at the foot of Nelson's Column were cast in separate pieces, and the lines of junction may be discovered on a close examination, though they are not at all perceptible when looked at from an ordinary distance. Another advantage in the adoption of this plan consists in the saving of material, as such figures are always made hollow.

Bronze is used for making bells and gongs on account of the sonorousness of this alloy. The most approved proportions are 78 per cent. of copper and 22 per cent. of tin; 69 per cent. of copper and 31 per cent. of tin also makes a very hard and sonorous material; but the proportions and even the constituent metals are often varied, a very common mixture being 77 per cent. of copper to 21 of tin and 2 of antimony. Zinc and lead are frequently introduced at the expense of both the principal ingredients, to make them more readily fusible, but the fineness of the tone is sacrificed at the same time. In bell-founding the metal is melted in a reverberatory furnace similar to that described in casting cannon, but the whole of the tin is not introduced at once, about one-third being added after the rest of the alloy has been thoroughly liquefied.

Speculum metal, used in the construction of reflecting telescopes, consists of an alloy of tin and copper in the proportion of two-thirds of the former to one-third of the latter. It is white, hard, and takes a very high polish: 73 per cent. of tin to 27 per cent. of copper also makes a very white and suitable metal for this purpose.

Another series of very useful alloys of tin is comprised under the general name of pewter; but they are distinguished among themselves by other and sometimes higher sounding names. Familiar instances of the use of pewter are beer pots and the common liquid measures. The former should consist of 83 per cent. of tin and 17 per cent. of antimony; but lead is very often used in part substitution of the latter metal, though the alloy suffers in respect of hardness in consequence. The commonest pewter contains 80 per cent. of tin, the remainder being lead. When so large a proportion of the last-named metal is used, there is some danger of its affecting injuriously the liquids which may be put in the vessels, especially if they should be at all acid. A harder pewter, used for making dishes, is obtained by the addition of a little copper.

The Britannia and Queen's metals, which are largely employed in the manufacture of coffee-pots and the like, are also different varieties of pewter. The former is a compound of copper, zinc, tin, antimony, and bismuth, the relative proportions of which differ considerably according to the fancy of the manufacturer. The latter consists principally of tin, with a little antimony, bismuth, and lead. In both cases the alloy is moderately soft, and fusible at a comparatively low temperature. Most of the utensils made of these are cast in brass moulds. These are made in separate pieces, fitted together with great nicety, and held firmly in a frame. The interior surface of the mould is rubbed with oil, or some other composition which shall prevent the molten metal from sticking to the brass. When cool the mould is pulled to pieces, and the vessel inside only needs trimming and polishing. Many hollow vessels are made on a wheel upon a principle somewhat analogous to that on which a potter forms cups and vases, only in this instance the instrument which fashions them is made to revolve and the sheet of metal is pressed against it; the body being thus formed, if handles, feet, or spouts are to be added, they are made separately, and then soldered on with a fusible alloy of tin, bismuth, and lead.

Tin is an important ingredient in many varieties of solder. That used by pewterers consists of the metals above named in variable proportions, according to the character of the work for which it is required. 50 per cent. of tin to 25 per cent. of lead and an equal proportion of bismuth form an approved mixture; at other times 33 per cent. of tin to 45 per cent. of lead and 22 per cent. of bismuth are employed in preference. Plumbers use a combination of tin and lead: two-thirds of the former to one-third of the latter forms a solder which has a melting-point of about 350° Fahrenheit; a mixture of one-fourth and three-fourths respectively makes a less fusible alloy, as it only melts at about 500°. The most fusible of all the compounds of these two metals is a solder composed of 60 per cent. of tin to 40 per cent. of lead, which melts at 334°; whether the proportion of either the one or the other constituent be increased, the melting-point will rise, though the advance will be the more rapid if the increase be on the part of the lead. The solders containing bismuth are still more fusible; an alloy formed of equal parts of the three metals will melt at 254° Fahrenheit; and if the tin amount to 45 per cent. and the remainder consist of lead and bismuth in equal proportions, the melting-point will be as low as 202°, or 10° below the boiling-point of water.

Tin is also an article of great importance to dyers. Several of the solutions of this metal, which are used by them as mordants and for brightening colours, have been already referred to in Articles II. to V., inclusive, of "Chemistry applied to the Arts," which treat of dyeing and calico-printing. Those in most general use are the chlorides of tin; more rarely the acetates and oxalates. In combination with the alkaline metals, as stannate of soda or potash, it is also of much service in fixing vegetable dyes. The chlorides are made by dissolving the purest grain tin in hydrochloric acid, or a mixture of that and nitric acid. The tin should not be all put in at once into the acid, lest the action and heat evolved should be too rapid, the best solution being that which is prepared most slowly and with the least evolution of fumes. They are used in producing scarlet with cochineal. The stannates, which are prepared by decomposing the perchloride of tin with an excess of caustic alkali, are much used in producing what are called by dyers "steam colours," the dye being fixed in their case by the oxidising action of the steam.

Some other applications of this metal, and those not by any means the least important, must be reserved for the next article.

SHIP-BUILDING.—VII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF IRON SHIPS.

In dealing with this subject it will be advantageous to glance at the ordinary or "transverse" system of framing merchant ships, before proceeding to notice other methods of construction. A very common arrangement is shown (in transverse section) in Fig. 20, reference to which will render our description clearer.

The main frames of ships built on this plan lie in vertical transverse planes, just as the amidship frames of a wood ship lie. They are usually formed of three parts—viz., the "frame angle-iron," which is fitted against the outside plating and rivetted to it; the "reversed frame," R, which is set back to back with the frame angle-iron (in the enlarged section at B B) and rivetted to it; and the floor-plate, which stretches from side to side across the keel, and rises to the height C. At that point the frame angle-iron and the reversed angle-iron are separated, in order to admit the floor-plate between them, the former being connected to the lower edge of that plate, and the latter to its inner edge (as shown by the enlarged section at A A). From the floor-plate upwards the frame shown consists simply of two angle-irons set back to back and rivetted together, thus forming a double-flanged girder of great efficiency as compared with a solid timber of square section. It is usual to continue the reversed angle-irons on alternate frames up to the upper deck in all except small ships, and on the intermediate frames to end the reversed angle-irons further down. Into these details, however, we cannot enter.

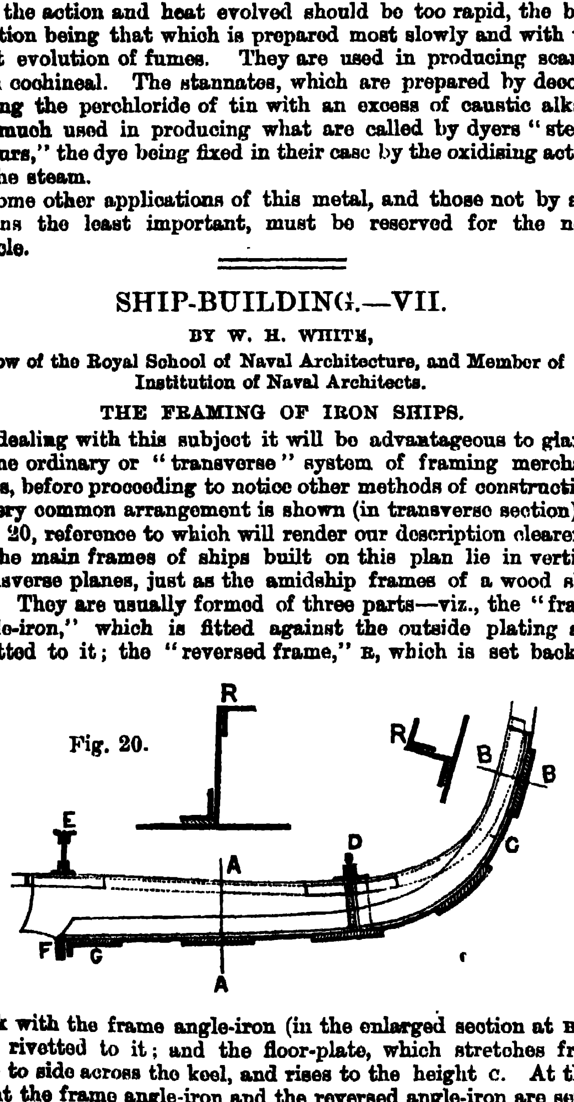
Fig. 20.

The angle-irons for the frames and reversed frames can now be often obtained in one length from gunwale to keel; and consequently the labour and expense of welding or strapping pieces together is saved, while the strength of the frames is increased, and the combination of the parts is much simplified. Floor-plates are usually made of two or three pieces welded or strapped together, but even when thus formed they are connected in a manner that is superior to any joint made in the timbers of a wood ship's frame.

The simplicity and strength of such a combination as this cannot fail to be remarked, when it is compared with the elaborate arrangements unavoidable in a wood ship's framing. Neither in providing the materials, nor in shaping them to the desired form, nor in combining the various pieces, has the iron ship-builder any serious difficulty. The angle-irons are heated, bent, and bevelled with ease; the floor-plates are also readily fashioned; and the whole frame can be completely fastened together before it is raised. In fact, it is by no means uncommon to find the deck-beams also fastened to the frames before they are hoisted into place, and this operation can be performed without causing any considerable change of form in the frames—a good evidence of their individual strength.

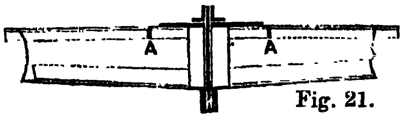

Fig. 21.

When treating of the transverse strains of ships, in a former paper of this series, it was pointed out that the resistance offered to any changes of form by the framing, plating, etc., at a cross-section, resembled that of a hoop-shaped girder. It may not be out of place here to consider this matter a little more closely, and to attempt to gain an idea of the respective uses of the parts of a frame, such as is shown in Fig. 20. In ordinary iron ships the distance between such frames would be something like two feet, so that we may suppose each frame to have as its duty the support of a foot-broad strip of plating on either side of it; which strip of plating, being rivetted to one of the flanges of the frame angle-iron, also helps to stiffen the frame. This mutual support is obviously an advantage as well as a necessity; but the use of the reversed frame, R, is a no less important feature, seeing that it provides an inner flange which would otherwise be wanting to the sections of the frame both at A A and B B. The outer flanges of those sections are necessarily large and strong for the reason just stated, and in order to fully develop their strength it is desirable to make the inner flanges also as strong as possible—in other words, to use large reversed frames.

The advantages resulting from the use of floor-plates are also obvious. By this arrangement great strength is provided, with a comparatively small expenditure of material, at a part of the ship where severe local strains as well as considerable bending strains may naturally be expected to occur. If, for example, a vessel takes the ground on her keel, and is otherwise unsupported, there must arise a severe bending strain tending to break the floors across; but their great depth would probably enable them to resist all such strains. The greatest intensity of strain would, of course, be experienced near the middle-line, and as the distance from the middle-line became greater the strain would diminish; hence we find ship-builders gradually reducing the depth of the floor-plates from the keel out to the bilges. Neither floor-plates nor reversed frames were used in some of the earlier iron ships, the frames of which were made up of single angle-irons; but the weakness and disadvantages of the plan soon became apparent, and led to the introduction of this present arrangement.

In the case illustrated by Fig. 20 the keel is formed of bar-iron, and marked F. This is the most common form of keel, and it is easily worked, the bars being rolled in considerable lengths, and connected either by scarfs or welds. Many other forms of keel have, however, been used, and much might be said respecting them, did space permit; it must suffice to refer to one or two only. In Fig. 21 an arrangement is illustrated which is often used, and is known as the "side-bar" keel. The floors do not cross the middle-line, as in Fig. 20, but are abutted against a continuous "centre-plate," which projects beyond them both above and below. On either side of the lower part of this plate a "side-bar" is fitted, and by means of through-rivetting the three thicknesses are formed into a keel. The floor-plates are connected to the centre-plate by means of short vertical angle-irons, and other means are generally taken to strongly connect the two sides. One of the most common connections in such cases is made by passing a short angle-iron (such as A A in Fig. 21) through a slot cut in the centre-plate, and rivetting it to the floor-plates.

The strake of plating next the keel, marked G in Fig. 20, is usually termed the "garboard strake," and is a little thicker than the adjacent plating. Its lower part is flanged so as to fit against the side of the keel, and the garboards on both sides are secured by rivets passing through the keel. With the side-bar keel the garboards are similarly formed and fastened, and in this case great care is required in order to shift the butts of the side-bars, the centre-plate, and the garboards, and to avoid any specially weak section. With bar keels it is sometimes considered desirable to "rabbet" the garboard strakes into the keel, but this is a more expensive plan than that illustrated in Fig. 20, and is not so commonly used.

The only other kind of keel to which we shall refer is that known as the "flat-plate" keel. Hereafter an illustration of this will be given, and for the present it must be simply described as a plan which does away with the external keel, and substitutes for it a thick middle-line strake of plating. If in Fig. 20 we conceive the bar keel to be removed, and the garboard strake to be simply run across under the floors to the other side, a very good idea of the plan referred to will be obtained.

Whatever form of keel be adopted, it is usual to have the stems and stern-posts formed of solid bars or forgings. The simplest case is that where a bar keel is used, and the stem is strictly speaking a continuation of the keel, being, like it, formed of bar-iron. With either a flat-plate keel or the side-bar arrangement the same kind of stem would be used, but special means of connecting the stem with the keel proper would have to be devised. Much the same thing is true of the stern-posts, which are, however, obtained with more difficulty than the stems, being necessarily more or less elaborate forgings, according to the character of the vessel. In the case of a sailing ship or paddle-wheel steamer one post is sufficient, and it requires only to be so fashioned as to carry the rudder and be readily connected with the after-end of the keel, as well as with some portion of the hull of a ship. But in screw-ships two posts are usually fitted, and the forging required is much heavier and more elaborate. Still, even in such cases, it is customary to weld the whole into one solid mass before lifting it into place, and securing it to the keel.

Transverse framing is usually maintained throughout the whole length of iron merchant ships, with the exception of the stern proper. Very few iron ships have any cant-frames, nor is there the same reason for adopting such an arrangement as there is in a wood ship. The stern-framing of iron ships is of a very much more simple character than that of wood ships, and usually has for its base the aftermost square-frame, against which most of the canted stern-frames heel. It is scarcely necessary to add that even at the very extremities there is no difficulty whatever in bending and bevelling iron frames to the required form, and combining them with floor-plates; in fact, the only noteworthy differences between the framing at those parts and that amidships arise from the differences in the ship's form. As a consequence iron ships require no substitute for the deadwood of wood ships, nor have they usually anything equivalent to the apron or stemson commonly fitted in wood ships. Sometimes the bows of iron ships are strengthened by breast-hooks formed of plates and angle-irons. Such supplementary strengthenings, although of great value, are, however, not nearly so much required in iron as in wood ships; and it is no small advantage to the former class, that sufficient strength can be obtained in them without using large weights of material simply for the purpose of succouring and reinforcing parts that are in themselves weakly connected.

Towards the extremities of an iron ship the frame angle-irons often have considerable bevelling, and the rule is to place them so that their two arms, or flanges, may always contain an obtuse angle, or have what shipwrights term "standing bevelling." This rule is based upon the fact that angle-irons are found to be less weakened by opening them out from the right-angled condition in which the manufacturer supplies them, than they are when closed in, or worked to "under-bevelling." In order to carry it out, ship-builders place the frame angle-irons on the after-side of the floor-plates in the fore-part of the ship, and on the fore-side in the after-part. As the reversed frame is always placed on the opposite side of the floor-plate from that on which the frame angle-iron comes, it also has always a standing bevelling.

Without entering into further details, we must proceed to notice the provisions of framing usually made to strengthen an iron ship against *longitudinal* bending strains. It has already been pointed out that against such strains, which are by far the most severe a ship has to bear, transverse framing is altogether ineffective; and this fact will become clearer if the case of an iron ship is considered. At a cross section (such as is partly shown in Fig. 20) there must necessarily be a line of closely-spaced rivet-holes pierced in the outside plating, in order to secure it to the frame angle-iron, and such a line consequently forms an *unavoidably weakened section* along which the plating is more likely to give way than it is between the frames. Now if fracture occurred the transverse frame could obviously lend no aid to the plating, which could be helped only by some strengthening piece which *crossed* the weakened line. This is the great objection to the ordinary or "transverse" system of framing which we are considering. It was copied at first from the plan that had been long in use in wood ships, where it was a necessity. It has many advantages in point of rapidity of construction and cheapness, and it has the great advantage of being thoroughly understood on account of its long use. But its radical defect is that the main frames are available only against transverse strains, and ineffectual against the far severer longitudinal strains to which ships, and especially long ships, are subjected.

The earliest iron ships were comparatively short and small, so that the transverse system of framing answered very well in them; but as the lengths and sizes of ships have been increased it has become necessary to supplement the transverse framing by longitudinal pieces running throughout the length of the vessels. A very great variety of form has characterised the longitudinal strengthenings employed, but the common practice has been to fit the larger number from the turn of the bilge downwards, and to have only a few between the ending of the floors (C in Fig. 20) and the lower decks of ships. This arrangement has had the effect of strengthening considerably what we have termed in previous papers the "lower flange of the girder" formed by the ship, adding to its powers of resistance both to longitudinal bending strains and to local strains. As a matter of fact, ordinary iron ships much more frequently display weakness at their upper decks and top-sides than they do at the lower portions, so that there is reason to consider the strength of the bottoms as generally sufficient, although it may not be obtained in the best possible way.

The longitudinal strengthenings used are named "middle-line keelsons" (such as E in Fig. 20), "side-keelsons" (such as D), "hold-stringers," "bilge-keels," etc. Ordinarily the middle-line keelson in a ship with a bar keel is made to run along upon the inside of the reversed frames, as shown in Fig. 20, and underneath it a short piece of angle-iron is worked on the side of the floor-plate opposite to that on which the reversed frame is fitted, in order to strengthen the connection of the keelson and the framing. The I-shape shown in the sketch is commonly used, but "box keelsons," or keelsons formed of two angle-irons set back to back or having a bulb-plate between them, and other sectional forms are also employed. Similar differences exist in the forms of the side-keelsons used, as well as in the hold-stringers, the latter being very commonly formed of two angle-irons set back to back. There is obviously a great simplicity of workmanship in keeping all such strengthening *inside* the framing; but there is this serious disadvantage, that there is then no direct connection between the strengthenings and the outside plating which it is their great duty to succour. After much discussion the opinion seems now to be gaining ground, that it is preferable to sacrifice ease of workmanship to the other consideration, and to make at least some of the side-keelsons "intercostal," like D in Fig. 20, in order to directly connect them with the outside plating. On referring to the sketch it will be seen that the keelson D consists of short plates fitted *between* the frames or ribs (hence the name "intercostal"), of equal depth with the floor-plates at that place. The lower edges of these plates are directly connected with the outside plating by short longitudinal pieces of angle-iron; and their ends are secured to the floor-plates by other angle-irons. Their inner edges are overlapped by the lower part of a "bulb-plate" to which they are rivetted; this plate is continuous, as are also the two angle-irons connecting it to the reversed frames. Many modifications of this arrangement will at once suggest themselves to one acquainted with ship-building, but in all of these modifications the same principle of direct connection between the keelson and the outside plating ought to be carried out. In some cases builders have sought by similar means to make a direct connection between the middle-line keelson and the bar keel, but this is less common. With a side-bar keel (such as that in Fig. 21) the centre-plate forms a continuous longitudinal strengthening, and obviously combines keelson and side-bars in a very satisfactory manner. In that sketch also is shown an example of what is termed a "flat-plate keelson," examples of which are frequently met with in ships with other than side-bar keels. It may be added here that in vessels with flat-plate keels it is by no means uncommon to have a centre through-plate (or "vertical keel"), and other middle-line arrangements, resembling in character those shown in Fig. 21, with the difference of the keels.

In a large vessel there might be two or more side-keelsons between the middle-line and the turn of the bilge, besides hold-stringers above that height. The minimum numbers and dimensions of these strengthenings are stated in the rules which guide private builders, but in some cases more are fitted than the rules require. Bilge or side keels are also commonly used in order to strengthen large iron ships, being formed much in the same way as the hold-stringers, but rivetted on the *outside* of the bottom plating. Such keels, besides strengthening the ships, help to check both rolling and lee-way, and in most cases these are the primary objects for which they are fitted.

By all these arrangements considerable longitudinal strength is given to the lower parts of ordinary iron ships; but in order that the material used in the strengthenings may be properly efficient, great care is required in arranging and fastening the butts or scarfs of the various plates and angle-irons. It is possible, as we have seen, when iron is used to join two pieces together so that they will resist either tensile or compressive strains, and this fact makes it easy to form strong longitudinal ties in an iron ship and to supplement the transverse framing. But if no care is taken to secure the butts and scarfs of the keelsons, etc., they become worse than useless, and there have been very many instances of such neglect. That they may be thoroughly efficient, all such longitudinal strengthenings must be made to approach as nearly as may be to *continuity of strength*, and not left in detached pieces or stopped short at bulkheads. In order to render our meaning plainer still, we will consider what would have to be done in arranging and fastening the butts of the continuous bulb-plate and angle-irons in the side-keelson D in Fig. 20. Here three pieces have to be combined, and indirectly associated with the strake of outside plating to which the intercostal plates are attached. We will suppose the butts of this strake of plating to be fixed, then it would obviously be advantageous to keep the butts of the keelson clear of the butts of the plating. No difficulty would be experienced in doing this, because the bulb-plate could be rolled in lengths, say twice as great as the outside plates, and so also could the angle-irons. Starting, therefore, from the butts of the outside plating, it would be easy to place the butts of the bulb-plate clear of them, or to make them "shift;" and having fixed the latter, to place the butts of the two angle-irons so as to give shift to each other, to the butts of the bulb-plate, and to those of the outside plating. This operation is what we have termed the *arrangement* of the butts; but it is also necessary to care for their *fastening*, and in the case considered all the butts of both angle-irons and of the bulb-plate too should be strongly secured by straps. The illustration is a very simple one, but it will serve to indicate the kind of work that has to be done in many more difficult parts of the work of ship-building, in order to secure good combinations.

TECHNICAL DRAWING.—LVIII.

GOTHIC STONEWORK.

DECORATED WINDOWS (*continued*).

The window here given (Fig. 504) is a specimen of the flowing Decorated. An example of a simple character has been chosen, to enable the student to copy it without much difficulty. The divisions of the panes are therefore omitted, in order to show the centres from which the various curves are struck.

Towards the close of the reign of Edward III. the outlines of window tracery began to show a tendency to adapt itself to the vertical bearings of the mullions, instead of branching off from them in flowing undulations. This, the death-blow to flowing tracery, and with it to Decorated Gothic, gave rise to a new variety, at present known by the name of the Perpendicular style. Here, however, as in the previous changes, the alteration was very gradual, consisting at first merely of the introduction here and there of a perpendicular member into a design in other respects flowing in character; and this vertical bearing of the mullions is the foundation of all Perpendicular tracery.

Circular windows, filled with beautiful tracery, are often met with in large structures. Windows in the shapes of squares, trefoils, quatrefoils, spherical triangles, hexafoiled circles, etc., are also frequent, but are generally of small size, and are usually seen in subordinate situations, such as in clerestories, gables, etc.

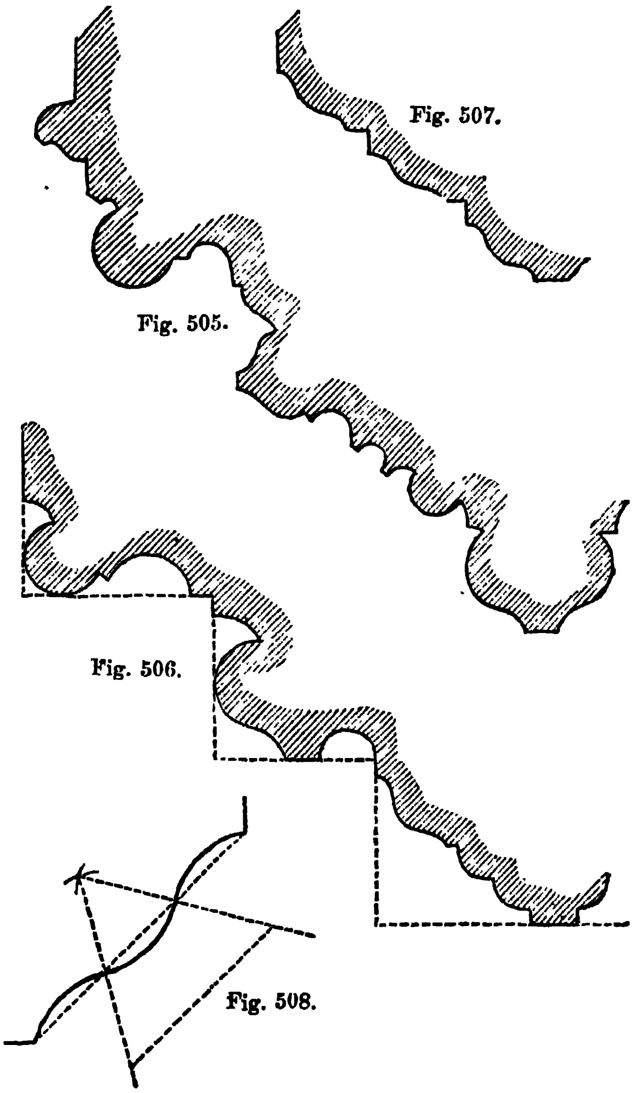

Fig. 507.

Fig. 505.

Fig. 506.

Fig. 508.

DECORATED ENGLISH BUTTRESSES.

These are not in some instances easily distinguishable from those of the Early English period, for they sometimes consist merely of plain piers, with one or more slopes or set-offs, without any further decoration; but in many cases they may be known by being set diagonally at the angles of the buildings, whilst, as has already been stated, those of the preceding periods were set at right angles to the two walls. Even this, however, must not be taken as an absolute rule, for some Decorated buttresses are similarly placed. The distinctions will therefore principally lie in the mouldings, the finials, crockets, etc. In rich examples the faces are often recessed for niches, which are surmounted by rich canopies, small buttresses, pinnacles, etc. The buttress seldom reaches above the parapet, unless surmounted by a pinnacle, which is mostly of an elaborate description.

The parapet is frequently used in the Decorated period, and is often pierced in various shapes—such as trefoils or quatrefoils—inserted in the spaces left on either side of an undulating moulding.

DECORATED ENGLISH MOULDINGS.

These are, as a rule, larger and bolder than those of the Early English period, and are arranged with a more studied regard to broad effects of light and shade. The somewhat monotonous similarity of numerous small members is no longer found, and the eye is at once arrested by two or three prominent forms, whose broad shadows produce the leading lines in a suit of mouldings, and divide the whole into masses, whilst numerous small mouldings produce a streaky effect. Fig. 505 is a section of the pier-arch of St. Oswald's, Chester, in which will be observed one prominent member in each order—a fine roll and fillet in the first; another differently set in the second; and a bold round and hollow in the third. So, also, in the pier-arch of the nave of the cathedral (Fig. 506), we have a remarkably bold roll and fillet in the second, and a roll and hollow in the third. "The effect of these," says the Rev. T. N. Hutchinson, and which the author has often observed, "is very striking when received in full sunlight." Fig. 507 is a section of the pier and arch moulding of one of the pier-arches, in Chester Cathedral, adjoining the central tower, and exhibits a form of moulding which is of constant occurrence in Decorated work. This is the "wave-moulding," or *swelled chamfer*. It is little more than an ordinary chamfered edge, with a slightly-sunk channel on each side, thus raising the middle portion into a curved or swelled form. The arch in question is of three orders, each chamfered with the wave-moulding. The curve of the wave-moulding is struck from the three points of an equilateral triangle (Fig. 508). A group of two or more wave-moulds, with intervening hollows, was a common and most beautiful Decorated arrangement.

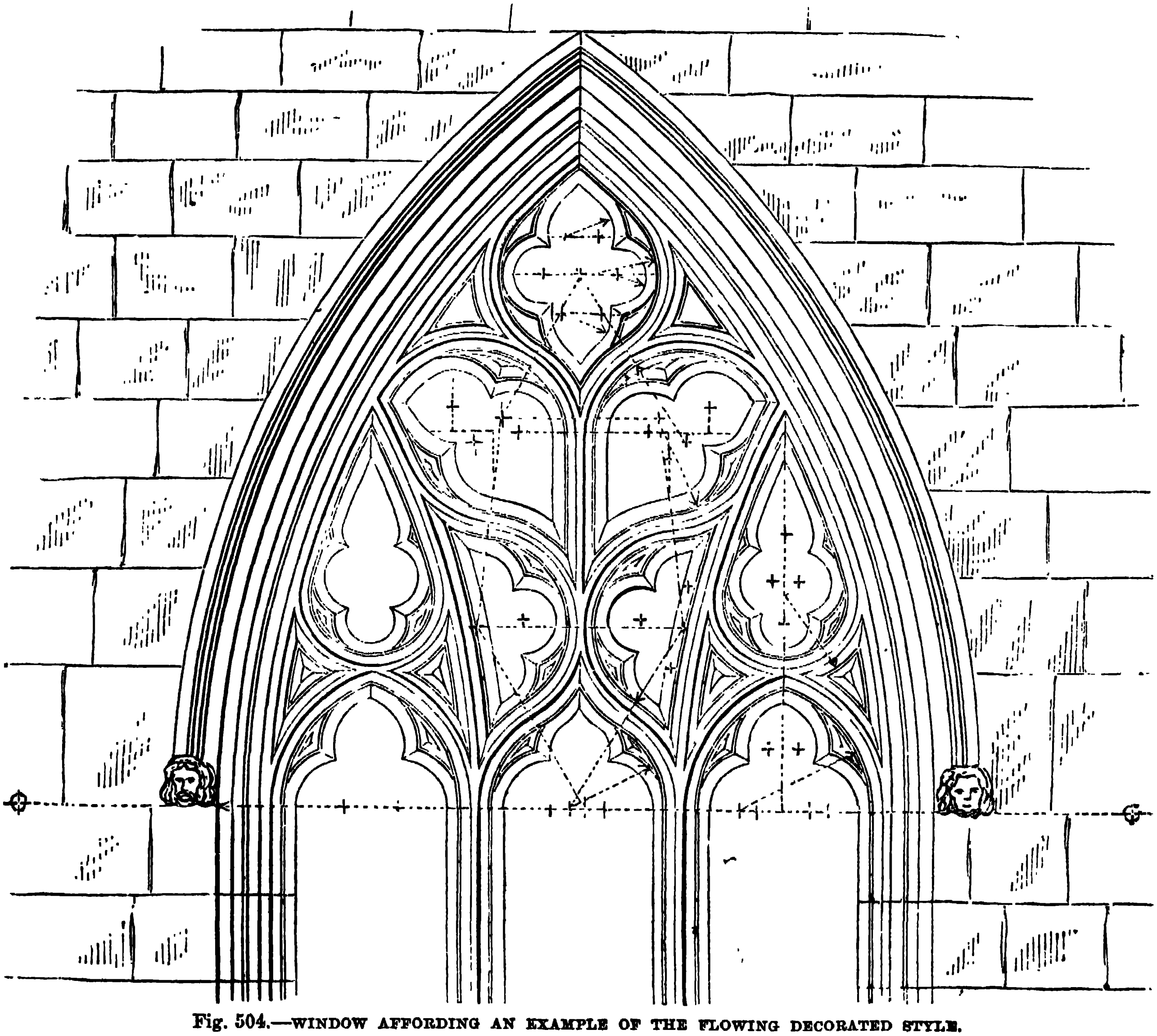

Fig. 504.—WINDOW AFFORDING AN EXAMPLE OF THE FLOWING DECORATED STYLE.

This moulding was also of frequent occurrence in Perpendicular, though belonging to the former period; its presence alone is, in the absence of other criterion, nearly sufficient to stamp an example in which it occurs as Decorated.

The method of covering flat surfaces with ornamental patterns in low relief has been spoken of in connection with the Early English, and it continued to be extensively used in the Decorated period. One of the most beautiful diapers of the time exists in Canterbury Cathedral. The design is composed of a flower of six leaves in low relief, within a hexagonal compartment, the sides of which are formed by the sides of six spherical triangles, and are foliated within. A great number of other beautiful patterns in diapers were used in this style. The origin of the name has been a source of dispute: it is supposed to be taken from a kind of cloth worked in separate patterns, and which was then, as now, much used under the name of *dyaper* or *diaper*, originally *d'Ypres*, the chief manufactory being at Ypres, in Belgium. Of this species of decoration, Mr. Brandon says: "It is a peculiar characteristic of pure Gothic that all mouldings, panelling, or sculpture were always sunk from the face of the work. Such an arrangement is the natural result of a style, a distinguishing type of which was *only to introduce ornament as an embellishment to construction*. Thus, a capital would naturally be corbelled from the pier, the better to carry the superincumbent weight; hence its subdivision into head mould, and bell and neck mould. Panelling resulted from a desire to enrich that which would otherwise have been a flat surface, and consequently was wrought out of the face already existing. A row of dog-tooth generally exemplifies very well how ornaments also were worked out of the block. As the debasement gradually crept in we find the contrary to have taken place."

SEATS OF INDUSTRY.—XXII.

PHILADELPHIA.

BY WILLIAM WATT WEBSTER.

THE story of the origin and growth of Philadelphia, the largest city in Pennsylvania and the second largest in the United States, is exceedingly interesting and instructive, and is in many respects peculiar and even unique. It is a striking example of the extraordinary influence that one or two energetic, philanthropic, and able men can, in certain circumstances, exercise over the fortunes of a town. Pennsylvania was originally colonised by Swedes, who settled there in 1638, under the protection of their native country. Previous to the conquest of the New Netherlands by Great Britain in 1664, considerable numbers of Dutchmen and Finlanders had also established themselves on the banks of the river Delaware. About eighteen years after this event, William Penn obtained a charter from Charles II. granting him proprietary and governmental rights over the province. During the years 1682 and 1683, large numbers of immigrants, chiefly members of the Society of Friends from Wales, arrived in Pennsylvania and purchased land. The foundation of a large town from the first formed a part of Penn's scheme of colonisation, and the rapidity with which he accomplished this undertaking was very remarkable, and probably unprecedented. In choosing the site on which Philadelphia stands, Penn showed great discrimination. The spot he fixed upon was a neck of land formed by the bending towards each other of the rivers Schuylkill and Delaware, about six miles above their junction. He justly described it as a situation "that seems to have been appointed for a town, whether we regard the rivers, or the conveniency of the coves, docks, and springs; the loftiness and soundness of the land and air;" adding that "of all places in the world" he remembered "not one better seated." In dealing with the Indians, Penn acted with praiseworthy prudence and justice. Notwithstanding his charter, he purchased the soil from them at an equitable price, and the young town in consequence seldom suffered from the hostility of the natives of the district. The policy then adopted was pursued by the Constituted Government after the American Revolution, when the State of Pennsylvania made additional purchases from the Indians. Philadelphia was also singularly exempt from other evils, such as scarcity of food, to which young towns placed in similar circumstances are usually subjected during the earlier years of their existence. By 1683 Philadelphia contained 357 houses, and three years later the number had been increased to 600. In 1684 the population was estimated at about 2,500. The town was formed on a well-defined plan, in which Penn is said to have attempted to realise the idea he had formed of ancient Babylon, and the existing city is, with slight modifications, built in accordance with the original design of its founder. In 1700 a Swedish church was built on the site of a wooden church which had been erected in 1677, five years before the settlement of the Welsh. The first American newspaper, the *Weekly Mercury*, was published at Philadelphia in 1719, and nine years later the *Gazette*, edited by Franklin, was established. There were 1,500 houses and 13,000 inhabitants in Philadelphia in 1744, and five years later, Dr. Benjamin Franklin, next to its founder the greatest benefactor of the city, and others carefully counted the houses, which were found to number 2,076, exclusive of 11 churches. In this same year, 1749, about 20,000 immigrants, one-half of whom came from Germany, and the other half from the north of Ireland, landed at Philadelphia. During the revolutionary wars, the city was the scene of several important events. There the Declaration of Rights was adopted and promulgated in 1774, and the Declaration of Independence was issued from it in 1776. In 1777 it was occupied by the British forces under General Lord Howe for nine months, and at that date its population amounted to 21,767. The convention that drew up the constitution of the United States met in Philadelphia in 1787, and in 1790 the first Congress under this Constitution assembled there. From that year till it was supplanted by Washington in 1800, Philadelphia was the capital of the Union, and it continued to be the most populous city in the American continent, till it was outstripped by New York, about a quarter of a century after the Declaration of Independence. The State Legisture also removed to Harrisburg in 1800, so that Philadelphia ceased to be the political capital of Pennsylvania at the same time that it ceased to be the seat of the General Government.

In 1810, Philadelphia contained 96,664 inhabitants; in 1820, 119,325; in 1830, 167,811; in 1840, about 200,000; in 1850, 340,045; and in 1860, 562,529. At the present time the city occupies about 12 square miles of ground, and is about 5 miles in length by about 3½ miles in breadth. It is divided into square compartments, the wide and well-paved streets crossing each other at right angles. The houses are plain structures built of red brick and marble, and there are five squares laid out as parks in different parts of the city. It is abundantly supplied with water, drawn from the Schuylkill by powerful and ingenious water-wheels, and collected in extensive dams and reservoirs erected at Fairmount, a picturesque eminence in the vicinity. The water-works cost 432,512 dollars. Philadelphia is remarkably clean and neat, but owing to the unbroken uniformity of its streets, it has a rather monotonous appearance. Most of the thoroughfares are planted with trees, and the steps of the outer stairs of a vast majority of the houses are constructed of white marble, and the tops of their outer railings are of brass. The contrast thus secured is very pleasing. A large proportion of the public buildings of Philadelphia, which compare favourably with those of any other city in the Union, are either wholly constructed or faced with the beautiful white marble, which is found in abundance in the marble quarries of the neighbouring counties of Montgomery and Chester. Among the edifices most remarkable for their architectural beauty are the Custom House, originally built for the United States Bank, a fine Grecian structure on the model of the Parthenon at Athens; the Pennsylvania Bank, a marble building which has on each front a portico with six Ionic columns; the Girard Bank, an edifice cased in marble and adorned with a Corinthian portico; Girard College, a noble pile entirely surrounded with a colonnade of Corinthian columns; the Merchants' Exchange; the Mint of the United States; the Post Office; and the Masonic Hall. The State House, where the Declaration of Independence was framed and signed, is the building most noted for its historical association. Independence Hall has been carefully preserved in the state it was in when the founders of the American Republic held their deliberations in it, and it contains a statue of Washington which, though executed in wood, is considered a striking likeness of "the father of his country." There is an extraordinary number of churches in Philadelphia, estimated at some 350, including about 60 Episcopalian, 71 Presbyterian, 30 Roman Catholic churches, and two synagogues. The United States Arsenal is an extensive establishment, and from the navy yard some of the largest men-of-war belonging to the Republic have been launched. In the north-west quarter of the city stands the State Penitentiary and County prison, a massive granite building in the castellated Gothic style, planned on what is called the panopticon principle, comprising upwards of 400 cells, radiating from an octagonal tower in the centre, where the sentinel has all the doors in view at once.

Philadelphia is noted for the number, extent, and excellence of its educational, literary, and benevolent institutions. It contains 4 colleges, 2 high schools, 54 grammar schools, and considerably more than 250 schools of lower grades, with edifices owned by the city. We shall give a special notice of some of the most important of these in our next paper, and show briefly the present state of the home and foreign trade and commerce of Philadelphia.

THE LATHE—V.

By Henry Northcott.

SLIDE-RESTS: THEIR USES AND ADVANTAGES.

It is seen that by double gearing and the employment of steam-power, any speed and any required force can be obtained, whilst the lathe rotates quite independent of any exertion on the part of the workman, although perfectly under his control. The turner's work consists consequently solely in applying and guiding the cutting tool, and to this he is enabled to devote the whole of his attention and energy. The labour for light or ordinary moderate heavy turning is neither fatiguing nor difficult; but when articles of large diameter have to be turned, considerable force has to be exerted simply to hold the tools against their cuts, and prevent them removing material where none is required to be removed. It is also quite impossible to keep the muscles perfectly still, and absolutely under control, so the tools are very apt to be unsteady also, and to produce untrue work. It is much more difficult to keep the tool quite still against a cut than to keep it moving in any required direction. It is an easier matter to turn an article of curved or irregular outline by hand tools than to produce a regular cylinder perfectly parallel or a perfectly plane surface by the same means, and the difficulty increases with the size of the article. When work of the latter kind became often required it was found necessary to substitute for the human hand some more rigid if less accommodating appliance for holding the tools against their cuts; and the instrument termed the "slide-rest," as now constructed, perfectly supplements the uncertainty of the unassisted hand, and for such work as in performing which the hand is most uncertain and unreliable the action of the slide-rest is very complete and efficient.

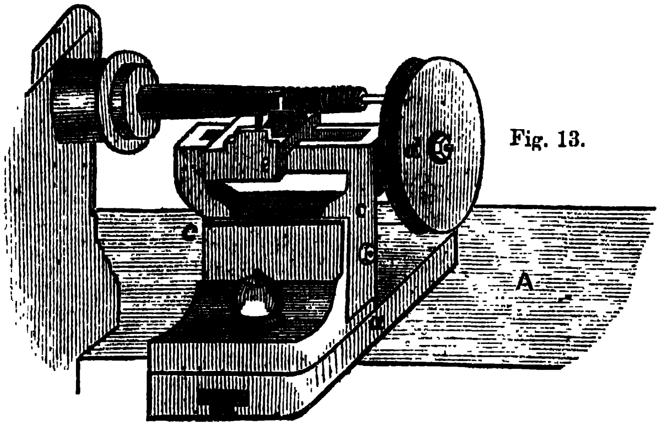
Fig. 13.

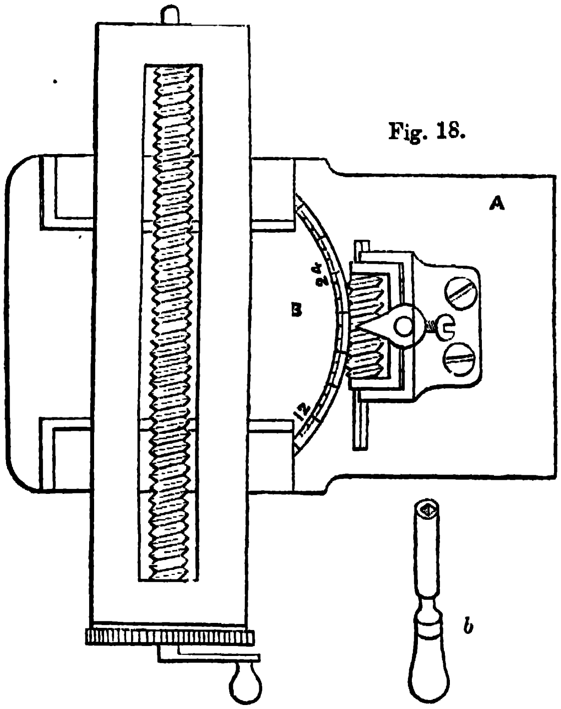
Fig. 18.

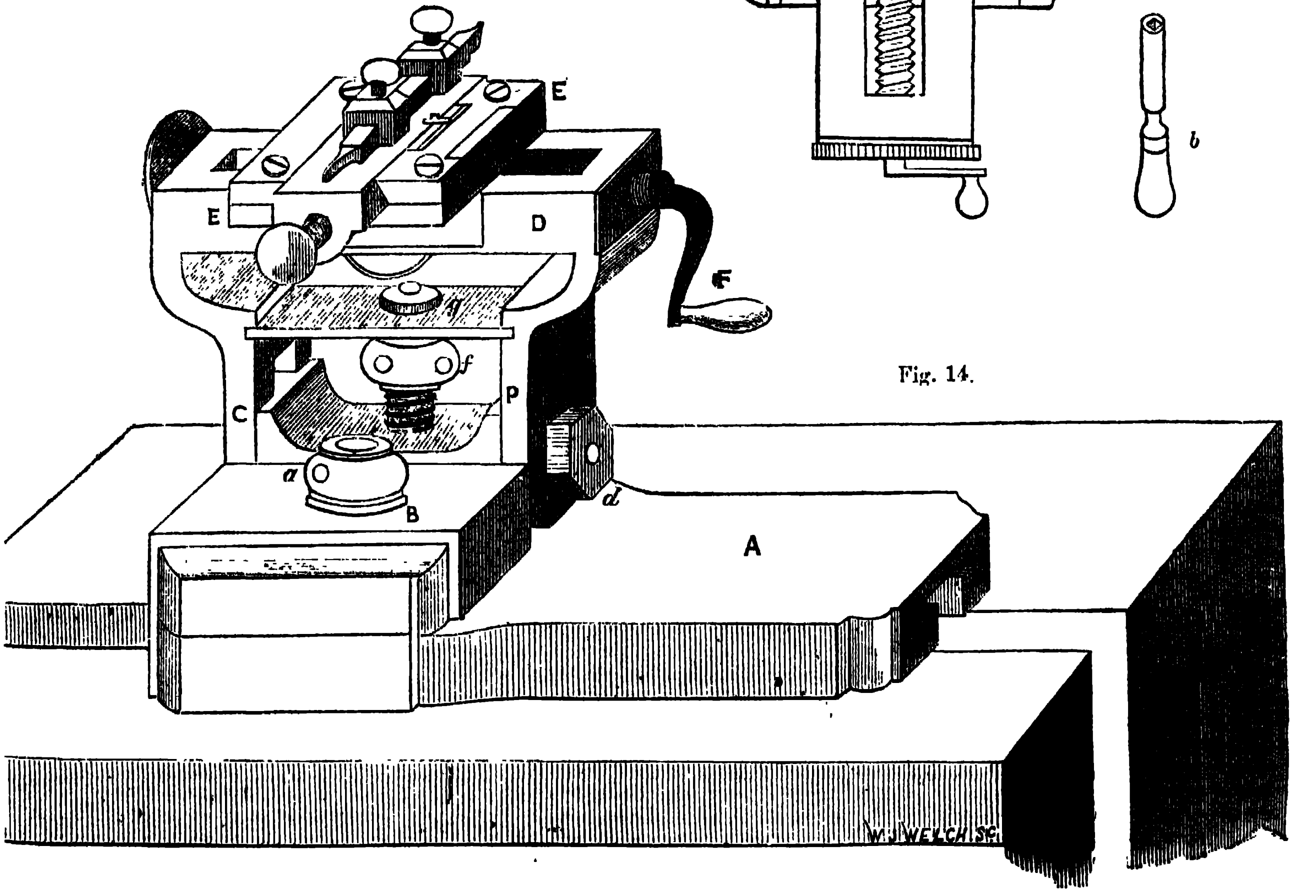
Fig. 14.

Suppose a piece of work in the lathe, and a tool held in some rigid holder in such a position that its cutting edge acted upon the work, then as the work rotates the tool will obviously cut away the projecting material and leave a plain ring or turned

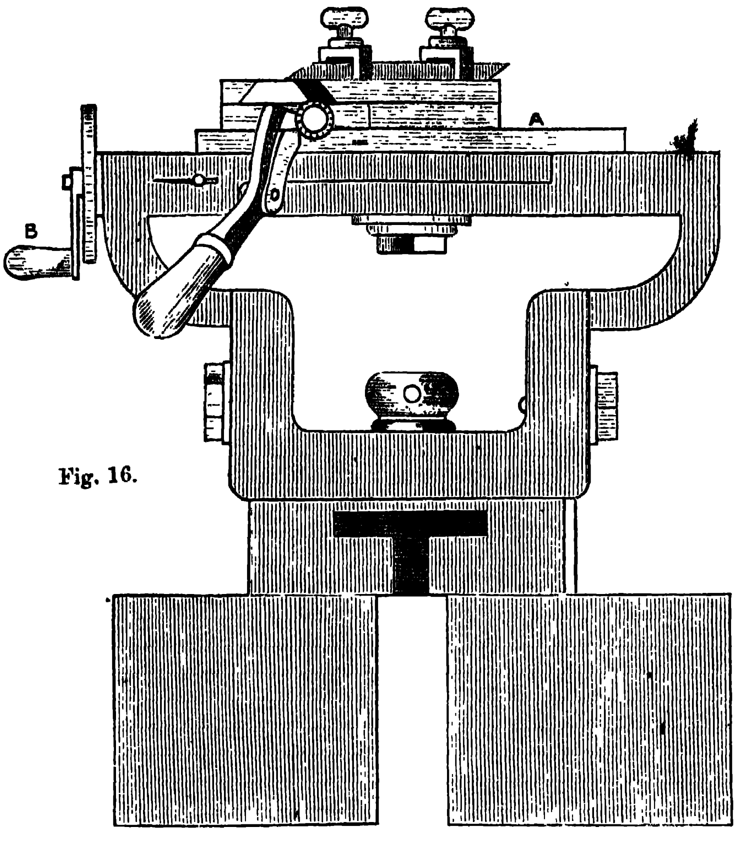

Fig. 16.

circle, as every part of the turned circumference will be equidistant from the axis. When the tool is held in the hand, if the diameter of the work be small, the tool may be still considered as held in a rigid holder whilst the work makes a single turn, and the figure produced upon the work a true circle, as small articles rotate too rapidly to be practically affected by any slight muscular movement. But when the article has a large diameter it requires to be rotated much slower, and a slight movement of the tool, causing the cutting point to go deeper or less deep into the material, results in the production of untrue or unsymmetrical work, as the figure produced by the moving tool upon the moving work is no longer a perfect circle, some parts of the outline being farther from the axis than others. This is obviated by using a rigid holder for the cutting tool, and if we imagine that this holder, and consequently the tool, is moved along the work a short distance after each rotation of it, we can conceive the principle of the slide-rest. If in making these changes of position care were taken to keep the cutting edge at the same distance from the centre line of the rotating work, a parallel cylinder would be produced. The main functions of the slide-rest are to hold the tool firmly to its cut during the rotation of the work, and to allow of the cutting edge being advanced after each cut in a given right line.

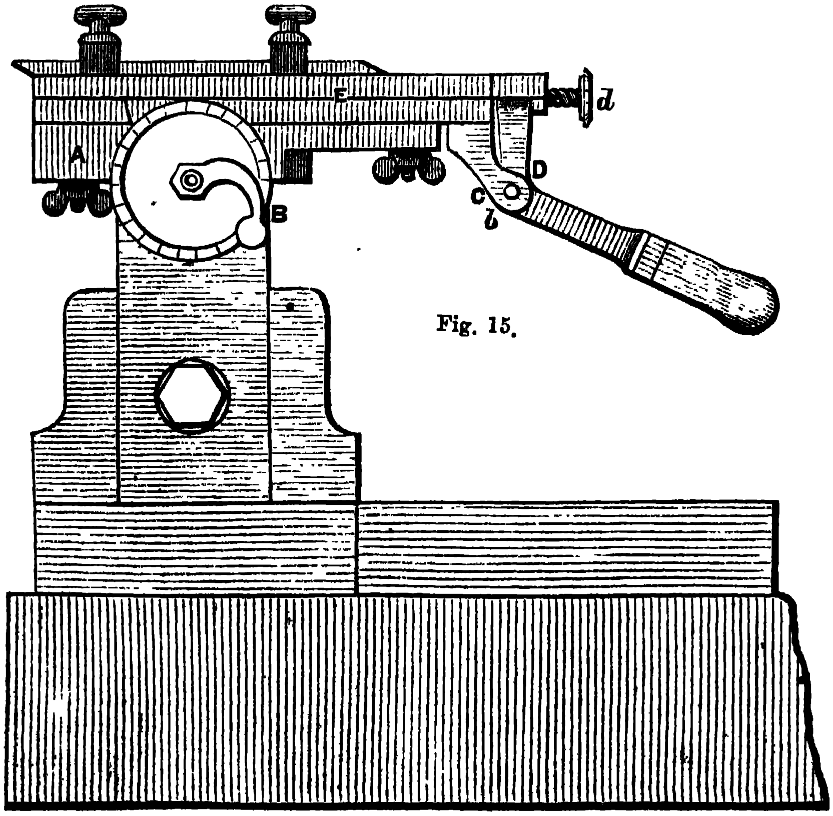

Fig. 15.

Although double gearing has been described first, so far as I can see the slide-rest was invented before it; and in Bergeron's excellent work (to which, and to Plumier's, as already mentioned, I am indebted for much information on the early forms of lathes, and early lathe work) there are several complete illustrations of this extremely useful instrument, which I here reproduce. Bergeron, in describing the slide-rest shown at Fig. 14, says, that seeing that these rests are particularly intended to turn square and oval work, that in turning these classes of work the lathe is considerably strained and shaken, and that this shaking is likely to affect injuriously the article that is being operated upon, it is advisable to make the rests wholly of metal, with a view of giving greater steadiness and stability to them, and lessening the vibration of the tools they carry.

The foot or hand plate, *a*, of the slide-rest described at Fig. 13 is much the same as the foot of an ordinary hand-tool rest, and is described as being made of brass. The bottom surface of it is brought to a true surface, and has a T-groove cut lengthwise in it underneath to receive the head of a bolt of corresponding shape, whose use is to fasten the foot and the mechanism it carries firmly down upon the lathe-bed, and which bolt-head is enabled to slide throughout the length of the T-groove, so that the rest may be fastened down upon the lathe-bed, A, at any required distance from the surface of the work to be turned. The part *b*, also of metal, is fitted nicely to *a*, the two surfaces in contact being rendered true and level, and they are held together by means of a bolt shown in front. The sides of *b* are fitted with two grooves forming slides for the reception of the two projecting feet or male slides, *c*. This arrangement of slides has for its object the adjustment of the height of the horizontal slide forming the top part of the part *c*. When the required height is decided upon, the position of *c* is maintained by tightening the two nuts at the outside of the slides. The bolt itself passes completely through both *b* and *c*, forming as it were a part of the former, and each end is furnished with the nut alluded to, by which the two parts are fastened firmly to each other. Only the right-hand nut is visible, but its position sufficiently indicates the place of the other. The upper ends of the two legs or slides of *c* are joined together by a bridge-piece formed of the same piece of metal, and this bridge serves as a horizontal slide for the small movable carriage upon which the cutting tool is mounted. The bridge-slide has a long slot through its length, and from its top surface to underneath the bridge. A small screw, *d*, passes from end to end of the bridge-slide, through the middle of the slot, and has its bearings in the metal of *c* at each end. Only the extreme end of the screw *d* is visible, as the chief part of it is hidden in the slot; the end visible is seen furnished with a pulley, but a small winch-handle would be used in preference to the pulley for moving the screw round by hand. The tool-carrier, *e*, is nicely made to slide evenly along the bridge-slide, and this movement is caused by the screw *d*, as a small projection forming part of *e* comes down into the slot, and there forms a nut for the traverse-screw. The configuration of the tool-holder and the position of the tool are sufficiently obvious from the sketch. This simple little apparatus contains everything necessary to render it an efficient sliding-rest or mechanical hand, and no doubt its use was found extremely advantageous in the production of light turned work formed of straight lines. It has provision for arranging its distance from the lathe-centres according to the size of work it was called upon to turn; it has provision for placing the carrying-slide at an angle so that the tool may be moved along in the direction rendered necessary by the required outline of the work; and it has provision for adjusting the height of the slide according to the thickness of the tool and the nature of the material to be operated upon. The tool-holder, also, is of very convenient form, allowing the tool to be quickly placed in position and easily removed for grinding or substitution. Altogether, this little slide-rest must be considered a very creditable production, and an important, because useful, invention.

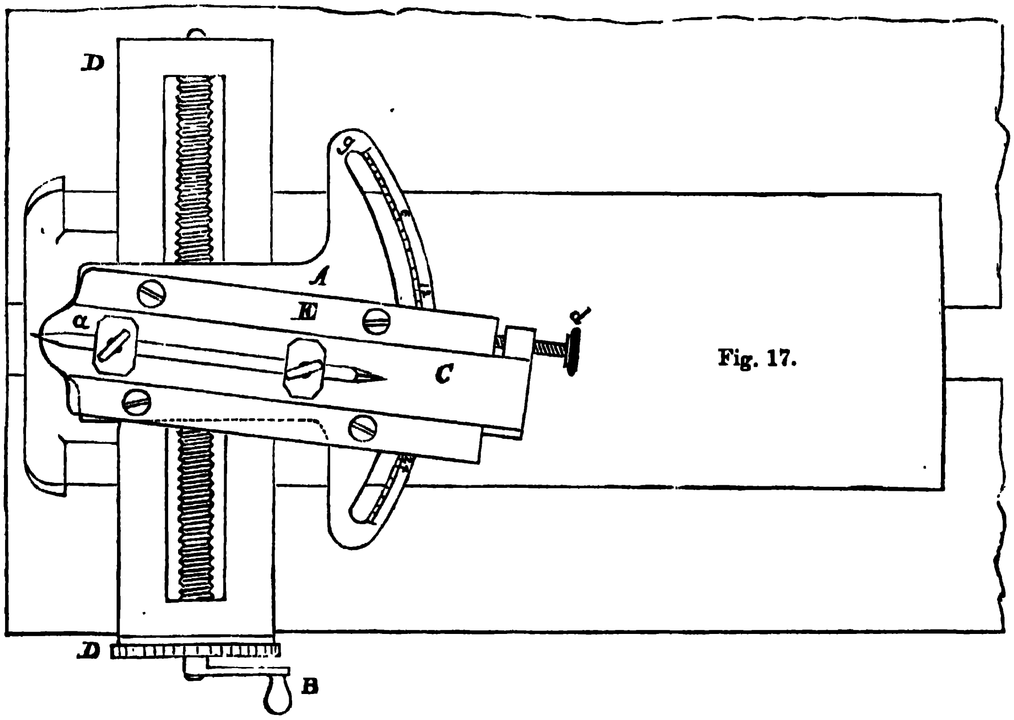

Fig. 17.

In Fig. 14 is shown a slide-rest of similar construction to the last, but more complete, and embodying some features of improvement. The foot, A, is of metal, planed underneath, and furnished with a T-groove for the head of the fastening-down bolt; B is formed also of metal very much in the same manner as the last; it is fastened down upon A by the screw *a*. The legs, P C, of the horizontal slide have forks cut in them, and are fitted upon two tongues of metal, being projections from B. This mode of fitting is to give the horizontal slide great stability, and prevent the rising slide being a source of unsteadiness. The position of the vertical slides is maintained by the screw *d* in the same manner as in Fig. 13, but the adjustment to the height required is made by means of the capstan-headed screw *f*, which screws into the metal of B below and rotates freely in the plate *g* above. The bridge-slide D has a slot through it, and carries the tool-slide E in much the same way as in the last example, the V-pulley on the screw being, however, here replaced by a winch-handle, F. The tool-slide, E, is much more complete than in Fig. 13, as it is provided with an additional slide at right angles to the slide D, and to this additional slide the tool is attached. Provision is also made in these slides for setting the cheeks of the slides closer together as they wear slack, and so prevent any shaking or unsteadiness of the tool, which would otherwise result from the wear of solid slides. The use of the additional slide is to regulate the penetration of the tool and the depth of its cut: the manner in which it subserves this purpose is readily seen from the engraving.

Another still more complete form of the slide-rest is shown in side and front elevation by Figs. 15 and 16, and in plan at Fig. 17. This slide-rest has two points of difference from the last we have described, and both points are embodied in the most modern slide-rests without any material modification. By referring to the illustrations it will be seen that the lower portion of the slide-rest is almost exactly the same as those already described, but the small carriage A of the horizontal slide D is continued outwards to form a broad flat plate with a long circular slot or groove cut through it. The edge of this circular slot is divided into degrees for convenience of adjustment. The carriage is moved along the slide by the usual screw, in the end of which is a handle B, and a circular plate divided on its edge as an index whereby the traverse of the slide could be seen and regulated. The top part of the carriage and flat plate is very nicely filed up to a true surface, and the bottom surface of a second plate E is similarly prepared and fitted down upon A. In front at *a* (Fig. 17) a small bolt passes down from E, and goes through A with a thumb-screw beyond; this bolt acts as a fulcrum or centre, around which the part E may slide upon A. At the back end of E another small bolt similar to the last passes down through the circular slot of the plate A, and has a thumb-nut beyond for tightening it up. The object of this arrangement is that the part E which carries the tool may be moved round upon A, and the point of the tool by this means caused to describe a circular arc. The radius would obviously depend upon the position of the tool's point in relation to the centre or fulcrum around which it was moved, and the length would be regulated by the divisions marked on the edge of the circular slot.

The tool is carried by a separate slide as before, and the tool is held in place by two finger-screws, which enable it to be easily removed. Instead, however, of the tool being moved into and out of cut by a traverse-screw, a lever D was employed for this purpose, which enables the movements to be produced with greater readiness and rapidity. This lever was carried by a lug, C, projecting from the slide E, and affording a fulcrum for the lever at *b*; one end was in contact with the tool-slide, and the other end furnished with a handle, as shown in Figs. 15 and 16. A small screw, *d*, at the side, best seen in Figs. 15 and 17, was employed to supplement the handle, and regulate and determine the depth to which the tool should cut.

This application of a lever for running the tool in and out is a great convenience for light ornamental turning, but it is not applicable to lathes intended for heavy turning or metal work. The circular motion of the tool-slide as here worked out was not of great value. The rest was intended for the production of spherical curves, but it was not well adapted to produce them, nor did the circular movement give any greater facility for the production of cones and angles; but in the next arrangement, as shown at Fig. 18, the position of the circular slide was altered and placed, as the reader will notice, below the main horizontal slide instead of above it.

In this slide-rest, the top surface of the foot or base-plate A was made smooth so as to form a part of the circular slide, the other part being formed by the plate B. This plate was fastened to A by a central bolt, which permitted it to turn freely round, and the outside edge of the plate B was cut with screw-teeth to form a segment of a worm-wheel, into which the tangent-screw or endless worm, *a*, geared. The tangent-screw was of course fastened down upon A. Upon the plate B was mounted the main slide, which latter was of the same form, and carried the same kind of tool-slide as in Fig. 15. The main slide only is represented in the engraving, to make the arrangement as little complicated as possible. In this slide-rest the circular movement of the top slide is brought about by moving round the tangent-screw *a*, a handle *b*, as shown in our illustration, being provided for the purpose.

The application of the tangent-screw was in itself an improvement, as the circular motion was thereby obtained in a manner much more equable and more under control. But by placing the long slide upon the circular slide, instead of the reverse, a much more convenient means was afforded of placing the slide at an angle to the line of the lathe-centres, when conical or angular work had to be turned. The slide-rest was, even with the successive improvements we have already noted, still not well adapted to act as a spherical rest; but with the tool-slide shown at Fig. 15, and the circular movement of Fig. 18, it had become a very useful adjunct to the lathe.

CHEMISTRY OF THE FINE ARTS.—IV.

By Professor CHURCH, Royal Agricultural College, Cirencester.

GUM, GLYCERINE, HONEY, AND GLUE—LIME—WATER-GLASS: ITS PREPARATION AND PROPERTIES.

THERE still remain for consideration a few materials of organic origin, which are employed in certain processes of painting. Of these organic products some of the gums are of importance, especially in connection with the use of water-colours. *Gum arabic*, a natural exudation from several species of *acacia*, is a much more highly oxygenated substance than any of the materials studied in our last lesson. Its specific gravity, when white and pure, is 1·36, and it is completely soluble in cold water, but insoluble in spirit. It contains a slightly acid substance, called arabic acid, united with lime, potash, and magnesia; its per-centage composition is—

Arabic acid	71
Water	18
Lime and salts	11
	100

Gum arabic may be partially purified from salts by boiling its powder in alcohol, which is then to be poured off. Or it may be completely freed from extraneous matters by the addition of acetic acid to its solution, and the subsequent dialysis of the mixture, pure gum remaining on the dialyser at the end of a few days. *Gum Senegal* closely resembles gum arabic, but is somewhat more tenacious, and is nearly free from saline matters. Its specific gravity is 1·44. These two gums serve, when in solution, as media for water-colours, solid coloured particles remaining long suspended in them, and being also thus bound together and to the paper or other painted surface. The gums also exert some protective influence on the pigments with which they are mixed, and thus correspond to the resinous and other vehicles of oil-painting. Gums, however, afford no security against water or even damp; while some of them, if freely used in painting, actually encourage moulds. A solution of gum arabic may be kept sweet, and free from acidity or fungi, by means of a lump of camphor kept floating in the bottle, or by the addition of less than 1 per cent. of pure carbolic acid. Dextrine, British gum or mucilage, a substance derived from starch, must be carefully avoided in all artistic work; it is specially prone to change.

Many years ago the writer of these lessons tried some experiments on *glycerine* as an addition to gum-water or to isinglass solution in the preparation of moist colours; used sparingly it proved very useful in preventing some coloured layers from cracking, and also in preserving the pans of coloured substances in a working state. The best distilled glycerine must be employed, and as it attracts moisture from the air, it can only be introduced into pigments in very minute proportions. The liquid part of honey which has been kept some months, or the sugar extracted from honey by cold alcohol, may be substituted for glycerine. In preparing this sugar by the alcohol method, the spirit must be distilled off in a retort; the remaining syrup is known as fruit sugar or fructose.

The presence of the element nitrogen to the extent of 17 per cent. in glue, isinglass, gelatine, and size, renders these substances very distinct, in a chemical point of view, from those which we have just studied. They are liable, under many conditions, to change; and as they contain nearly 1 per cent. of sulphur, this change is sometimes attended by the separation of sulphur compounds injurious to lead-pigments. From whatever materials the "size," or solution of these nitrogenous matters, be prepared, its purity is of great importance. Russian isinglass, prepared from the lining membrane of the swimming bladder of the sturgeon, affords one of the best kinds of size when dissolved in boiling water and strained through muslin. Ivory dust, vellum and parchment-clippings, fish-bones, and several other similar materials, yield a clear and colourless size by sufficiently prolonged boiling in water. Whatever crude substance be taken, it should be thoroughly washed in pure water, soaked in lime water, and again washed before being converted into size. If white of egg or the albumen of blood be employed, it should be purified by dialysis, as already described under the head of gum.

We must now turn our attention to one of the most important art-materials which we have yet mentioned—*lime*. This substance forms the basis of all the grounds used in distemper and fresco painting, and is employed in two states, as carbonate of lime and as hydrate of lime, compounds which in modern chemical language are termed respectively "calcium carbonate" and "calcium hydrate." When chalk, marble, or limestone is strongly heated or "burnt," it loses the carbon dioxide or fixed air which it contained, in accordance with the equation—

$$CaCO_3 = CaO + CO_2.$$

The CaO remaining is burnt lime, quicklime, or caustic lime. Perfectly pure limestone should yield 56 per cent. of quicklime. When quicklime is placed in water or wetted it absorbs water, becoming slaked, but still retaining its caustic or alkaline character—

$$CaO + H_2O = CaH_2O_2.$$

100 parts of pure burnt lime absorb 33 parts of water. Now, when slaked lime, which is a white dry powder, is exposed to the air, it slowly absorbs carbon dioxide (CO_2), becoming at last re-converted into the original carbonate from which it was made—

$$CaH_2O_2 + CO_2 = CaCO_3 + H_2O.$$

With reference to lime compounds for artistic uses, two questions are suggested. From what native materials should they be prepared? and in what condition should the products be employed? It does not appear that the native lime compound taken need be very pure. It may contain bitumen, as in black marble; or magnesia, as in dolomite; or traces of silica, alumina, or iron, and yet yield a good lime. Still, the nearer the product approaches to pure lime, or to a mixture of pure lime and magnesia, the less probability is there of any drawback arising from its use. The next point is the slaking and preparing the lime. This is accomplished by mixing it with water and introducing it into a grouting box, the sluice of which is an inch or two from the bottom. When the slaked lime is reduced to the consistence of a cream, the sluice is opened, and the semi-fluid mixture allowed to flow out. With this mixture a covered pit dug in the earth, or made of brick or stonework, or better still a tank of slate, is filled. Here the white paste remains, covered loosely, for two months, when it is ready for all the rougher processes connected with fresco and distemper painting. For finer purposes and for use as a pigment or admixture with pigments, the lime must be again submitted to the grouting operation, strained through hair sieves, and run into earthenware jars. Here the water which collects at the surface is now and then poured off, while the white paste below will be found soft and easy to work, free from grit and salts, and to have lost some of its causticity, having become slightly carbonated. As long as it is kept in a closed jar it cannot become less caustic, nor is it desirable that this change should proceed to any great extent, or the binding and hardening properties of the material would vanish; not more than one-third of the lime should become carbonated previous to use. If it be dried and then again moistened, or if it be mixed with carbonated water (soda-water) and then allowed to settle, carbonation may be accelerated. On the other hand, as lime-paste apart from the air suffers no injury, it may be kept in cellars, in closed jars, for years, with the certainty that it cannot then produce any of those blisters or other defects in fresco paintings which irregularly slaked lime is known to cause. A large quantity of such old lime-paste, of excellent quality, is stored in the cellars of the Houses of Parliament; the present writer has made many experiments with it, proving that the bad condition of the frescoes painted with this material is due, not to any defect in it, but to such entirely different causes as the injurious action of coal-gas, a London atmosphere, etc. etc., and possibly in part to the inexperience of the artists in the peculiar method of painting required. There can, however, be no question that while slaked lime may be long kept and still preserved in good condition, a shorter period after slaking is sufficient to allow of that complete hydration of the quicklime, which prevents blisters being formed on the surface painted with it. Great confusion exists in the minds of fresco writers on this point, for while they rightly recognise different degrees of causticity in different limes, they rarely attribute these variations to the true cause, namely, the absorption from the air of carbonic acid gas, the gas that is now generally called carbon dioxide. It is, however, absolutely necessary that this combination should not have completely destroyed the caustic property of the lime. If it has proceeded very far, the lime has scarcely more binding power than common chalk or whiting, and will serve neither to make a firm ground for the picture nor to cement the colours to the surface. When two-fifths of the lime are carbonated—easily ascertained by a rapid analysis—it is in an excellent condition for fresco grounds, though it may be used in a still less caustic state for mixing with pigments. In speaking in the next lesson of the actual processes of painting, we shall have occasion to recur to the subject of lime.

Of the materials employed in silicious painting it will now be necessary to say something. We begin with a brief account of *water-glass.*

Water-glass, however it may vary in the exact proportion, and even nature of its constituents, is essentially a soluble alkaline silicate. Four varieties of it have been used in silicious painting, the first containing potash and silica, the second soda and silica, the third being a mixture of the first two, and the fourth being one of the former kinds rendered more strongly alkaline. These varieties of water-glass may be prepared by two distinct processes. In one of these, flints or other silicious materials are heated in closed iron vessels with soda or potash lye; in the other process the silicious substance is fused with an alkaline carbonate. The latter method is more easily managed under ordinary circumstances, and gives a very satisfactory and pure product. In adopting the other process, it is advisable to heat the flints, etc., red-hot, and to quench (*étonner*) them in cold water before introducing them into the vessels in which they are to be heated with the caustic alkaline liquor, under a pressure somewhat greater than that of the atmosphere. By fusing quenched and powdered quartz or washed silver sand, 15 parts, with 10 parts of purified potash, and a little charcoal, either in a graphite crucible or on the hearth of a reverberatory furnace, a clear glass will be obtained after some five or six hours. This is to be poured out on a slab, broken up, and boiled with pure water till it has almost completely dissolved. By subsequent evaporation of the solution (strained, if necessary, through a little asbestos or pumice, but not through paper), a liquor is obtained which contains silicate of potash or potassium silicate in solution, and which has a specific gravity of about 1·25. A soda water-glass is obtainable by a precisely similar series of operations, adopting, however, the following proportions: 45 parts of quartz, 23 pure dry carbonate of soda, and 3 of powdered charcoal. A mixed water-glass is furnished by the fusion of the following mixture: 50 parts quartz, 14 parts dry carbonate of potash, 11 parts dry carbonate of soda, and 3 parts of charcoal. These materials are much more easily and rapidly fused than those previously named. The solution which the product from them yields is probably the best material that can be employed in stereochromic or silicious painting. If, however, it should be saturated with silica, which may be the case, it is advisable to employ it only after it has been rendered more alkaline by the addition of a little caustic potash. The quantity to be added may be ascertained in the following way:—We shall find our water-glass solution somewhat opalescent; to it we add a 10 per cent. solution of caustic potash, with constant stirring, until the opalescence has disappeared. The quantity used for this purpose being noted, a further addition is made of one-quarter the amount.

An impure solution of water-glass may be rendered better fitted for stereochromic work by precipitation with from one-fourth to one-third its bulk of methylated spirits of wine, and collecting, pressing, washing slightly, and finally re-dissolving the gelatinous precipitate thus obtained. Chlorides, sulphates, sulphides, and sulphites are objectionable impurities in a water-glass. It is a mistake to have the water-glass solution neutral. If not distinctly and even strongly alkaline, a white silicious bloom will form on the painting executed with it. On the other hand, a great excess of alkali is objectionable, for it may favour the production of a saline efflorescence, and prevent the colours from drying and hardening properly, and exert a prejudicial influence on some pigments which might otherwise be safely employed.

The composition of *neutral* water-glass is represented by the chemical expressions—

Potash water-glass	$K_2O,4SiO_2$;
Soda water-glass	$Na_2O,4SiO_2$;
Double water-glass	$KNaO,4SiO_2$.

It might be supposed that these silicates of the alkalies would suffer double decomposition with the limestones and calcium carbonates with which they come in contact. This seems scarcely to be the case; but they form double compounds with them instead. So there is but little sodium carbonate formed when sodium silicate and calcium carbonate are mixed together and kept some time. The reactions of water-glass with some other substances are, however, more pronounced. Zinc white is largely used in preparing grounds for stereochromy, and it is found to form a silicate of zinc and the alkaline metal, liberating a little alkali in so doing, however. Burnt or calcined magnesia sets still more readily with water-glass than zinc white: lime and its phosphate may also be employed in the preparation of water-glass cements and grounds.

GREAT MANUFACTURES OF LITTLE THINGS.—V.

BY CHARLES HIBBS.

PINS (*continued*).

THE difficulty of keeping a pin's head properly on its shoulders led to many attempts to produce the now universally-known solid-headed pin. The first patent for the purpose of which we have any record in England was taken out by Timothy Harris, of Waltham Abbey, in the year 1797. His method was to *cast* the heads upon the shafts, employing for the purpose a mixture of lead and antimony. Two years previously to this, however, a patent had been taken out in France for making pins, the head and shaft of which should be of one piece, but of this we have no detailed description. But neither of these patents seem to have revolutionised the trade, for twelve years later we find a patent by William Bundy, of Camden Town, for an improvement in the method of fixing the old-fashioned wire heads. He simply proposed to rivet them on a dozen or two at a time, instead of singly. The pins were placed in a pair of grooved dies, which were then screwed tightly together. The heads were placed on by the fingers, and a third die, under a fly-press, fastened them all at one blow. This method was soon abandoned, being, if anything, more tedious than the original one. In 1812 the firm of Bradbury and Weaver, of Gloucester, made an automatic machine for placing the heads on the pins, conveying them to be rivetted, and afterwards removing them. This machine made a flat-shaped head, with a good finish, but did not conquer its incurable defect of slipping down the shaft. Five years later we see the first introduction upon the patent records of a plan for making the head out of the substance of the shaft. Seth Hunt, in 1817, claims the merit of making pins, "with head, shaft, and *point*, in one entire piece." The wire was fed up to a machine, and seized by a die; a pin's length was then cut off, and the die held it while the head was formed by compression; the same die still held it while the point was formed, which was accomplished by the die turning round four times each way, while a cutting wheel rose in a proper position to catch the point. This must have been an ingenious machine, but it did not succeed in making good a footing in the trade. The heads formed by compression were probably not very workmanlike in their appearance. In 1824 the first real practical step in this direction (as it afterwards turned out) was taken by Mr. Lemuel Wright. His machine, although not in itself a success, gave the cue to improvements which resulted ultimately in the machine we now have. Nevertheless, Wright's machine differed from those now in use in all but the main principles. The pins were made directly from wire carried on a reel to the machine, and drawn through straightening pegs. A pair of cutting nippers then severed the length of a single pin; a carrier took this to a bevelled roughened wheel, against which it was held and rotated; another carrier took it to a second wheel of finer cut, which finished the point; another carrier took the pin to a heading die, when the head was roughly formed by the pushing up of a punch; and a fourth carrier took it to another die, which finished the head, and the pin was complete.

Though it struggled on with great difficulty for many years, Wright's machine was destined, as we have hinted, to lay the foundation of the future trade. Many successive improvements to it were tried and discarded; many speculators took it up and abandoned it; many handsome fortunes were sunk in it; but at last, in 1833, nine years from the date of the patent, the first solid-headed pins were thrown upon the market, and have kept it ever since.

Leaving it for a moment, let us examine a few of the ingeniously complicated contrivances that were patented for the same object, while Wright's machine was in its nonage. In 1831 Daniel Ledsam and William Jones took out letters patent for a machine, which, after forming the heads of the pins by pressure, pointed them by a process which is thus described:—"To point the pins, they are fed from a hopper on to the periphery of a wheel, which is grooved to take the heads. The pins then lie parallel to the axis of the wheel, and pass between the wheel and a fixed curved lever, held by a spring against the periphery of the wheel. Both the periphery of the wheel and the surface of the curved lever are covered with washed leather, and thus a rotary motion is communicated to the pins. While moving thus, their points come in contact with a rapidly rotating file, which sharpens them."

In 1835 Samuel Slocum patented a machine, which is described as follows:—"By means of inducting rollers moved by a ratchet wheel, a length of wire sufficient for a pin is introduced, and enters what is called a 'spring chuck,' a number of which are situated round the periphery of a wheel. The chuck holds the blank, which is now cut off from the main wire. The heading frame advances, and the dies close firmly round that portion of the wire which projects beyond the chuck, while at the same time the heading punch strikes up a head between the dies. The head being thus formed, the wheel revolves till the next chuck comes into position to take a blank. The same movement, however, carries the first chuck opposite a stationary cutter, which trims up the revolving head of the pin, already shaped in the dies. The next movement brings the head opposite a small punch, which forces the head up to the chuck, and consequently drives the point out at the other side to be ready for the pointer, which it reaches at the next stage. It then passes successively to other cutters, which finish up the point; and, finally, it comes to rest opposite a 'hooking piece,' which draws it out of the chuck, and allows it to fall in some convenient receptacle."

The reader will, doubtless, think that these two machines would form very pretty mechanical toys for an exhibition. Of the same character is the following, patented in 1841:—

The pin-shafts, pointed and cut, are placed in a hopper, whence they pass, one by one, into a groove on a metal plate. A plunger pushes the pin into the jaws of a holder, which then travels laterally, till it comes opposite the heading dies. "The pin-shaft is taken between these dies, and left there by the holder, which returns for another shaft. This return movement of the holder brings a second holder to the shaft now in the dies. This holder takes the shaft, while the heading plunger upsets the head. Thence it carries the half-headed shaft, released from the dies, to a second heading plunger, which completes the pin."

Let us now return to Wright's machine. Though pins with solid heads were produced by it, as we have said, in 1833, such were the difficulties connected with its complete working, that for many years the pointing continued to be done by hand. The machine was further perfected by D. F. Taylor and Co., of Stroud, who carried on the manufacture by its use with very feeble success, and after four successive companies had taken it in hand, and made nothing of it, the whole plant was purchased by Messrs. Edelsten, Williams, and Co., now of Birmingham, about 1843. From that date the days of pin-making by hand were numbered. The new firm were thoroughly practical men, and in four or five years had durably established the trade upon a new basis.

It would take too long to describe the many modifications of Wright's original patent, which have made the present machine what it is: we must be content with endeavouring to convey some notion of its very ingenious construction. It seems to give one the idea of a very *handy man*; one whose deft fingers can perform two or three operations at once, without the waste of a tittle of time or energy. It could be put into a good-sized portmanteau, but it has as many contrivances packed into its small compass as a modern dressing-case. The wire, as we have said, is drawn into the machine direct from the coil, passing through straightening pegs. A pair of heavy iron fingers close upon it when it has reached a certain distance, and hold it while three quick, chopping blows are administered upon its head; "dubbing" it up into perfect and comely shape. A cutting instrument then comes into play, and cuts off the pin, just as the iron fingers unclose, and let it drop into an iron trough lying down the side of the machine at an angle of 45°, or thereabouts. The bottom of this trough is not closed, but is one long slot, just wide enough to let through the shaft of the pin, but not the head. The pins, therefore, soon find their way to an upright position, and travel down the incline, hanging by their heads, simply by their own gravity and the shaking of the machine. When they get to the bottom they turn a corner in regular order, the trough being continued, and follow each other in single file along the front of the machine, where the pointing wheels are revolving. As they pass along the slower gradient of this part of the trough, assisted by the vibration, and by the pressure of those behind, they come successively in contact with coarse and smooth rotary files, and become beautifully sharpened by the time they reach the end, and drop off into a pan.

The seemingly almost intelligent motions of this machine are directed by cams, which come into play at the proper moment by one revolution of the spindle. Our readers know what a cam is: it is simply a wheel with a lump upon it. Let us inspect, by way of example, the mechanism of that quick little iron fist which delivers its blows with such precision and effect. Its striking end is, of course, cut to the converse shape of the top of the pin-head; its arm, or shaft, slides easily between "journeys," and its other extremity is furnished with a roller. A spring underneath keeps this roller pressing on the periphery of a wheel fixed on the spindle. This wheel has three lumps upon it; and, as it revolves, it shoots forward the striking punch three times. In like manner, the iron fingers that hold the pin are normally kept open by the pull of a spring, but other wheels on the same spindle, which have lumps on the side instead of on the circumference, press against levers in the course of their revolution, and close up the fingers with a grip like that of a vice.

The sticking machine, which is of American invention, is of not less ingenious construction. As it does not come within the subject of pin-making proper, we have no need to describe it; but the neatness and celerity of its movements, and the accuracy with which it performs its work, would be very attractive to a spectator. Pins have an inveterate habit of lying sixes and sevens when in a heap, and this machine turns them about, reduces them to order, and marshals them in a row, with all the precision of a drill-sergeant, in a manner that is both simple and amusing. It is much more agreeable to watch these machines than those we have described, on account of the deafening rattle of the latter. Where twenty or thirty of them are at work in a single room, the "music of the mill" is of a distressingly ear-splitting character.

PAPER AND CARDBOARD MAKING.—V.

BY GEORGE TINDALL.

PAPER-MAKING BY HAND, AND FINISHING.

THE making of paper by hand is analogous to the process by machine, but instead of a continuous web of paper, each sheet is made by a separate operation, and the size of the sheet is limited by the power of the operator to handle the mould or framework in which it is made.

The process of preparing the pulp is precisely the same as for machine-made papers, and the pulp when ready is run into a large chest or vat and mixed with a sufficient quantity of water. The workman then, standing by the vat, takes the mould—which in this case acts both as the machine-wire and as the dandy-roll, and consists of a framework of the size required, of wire gauze if for a wove paper, and made like a laid dandy-roll but flat if for a laid paper, and having a loose frame or deckle around it, projecting slightly above the wire for regulating the thickness) of the sheet—and dipping it into the vat he withdraws it full of the pulp. He then gives to it a gentle undulatory motion, causing the pulp to form in an even, regular sheet as the water passes away through the mould, and hands it to the assistant, taking off the loose frame, which he places on another mould and repeats the operation, while the coucher turns the former sheet as it lies on the mould on to a piece of felt conveniently placed, and covers it with another piece of damp felt ready for the next sheet. This operation is continued until a sufficiently large pile of sheets and felts, placed alternately, is prepared, when these are taken to a press and subjected to considerable pressure to force out the water and compact the fibres together. When sufficiently pressed, the pile is taken out and the sheets are taken from the felts and placed in a heap one upon the other, and these are then taken back to the press and subjected to very considerable pressure a second time.

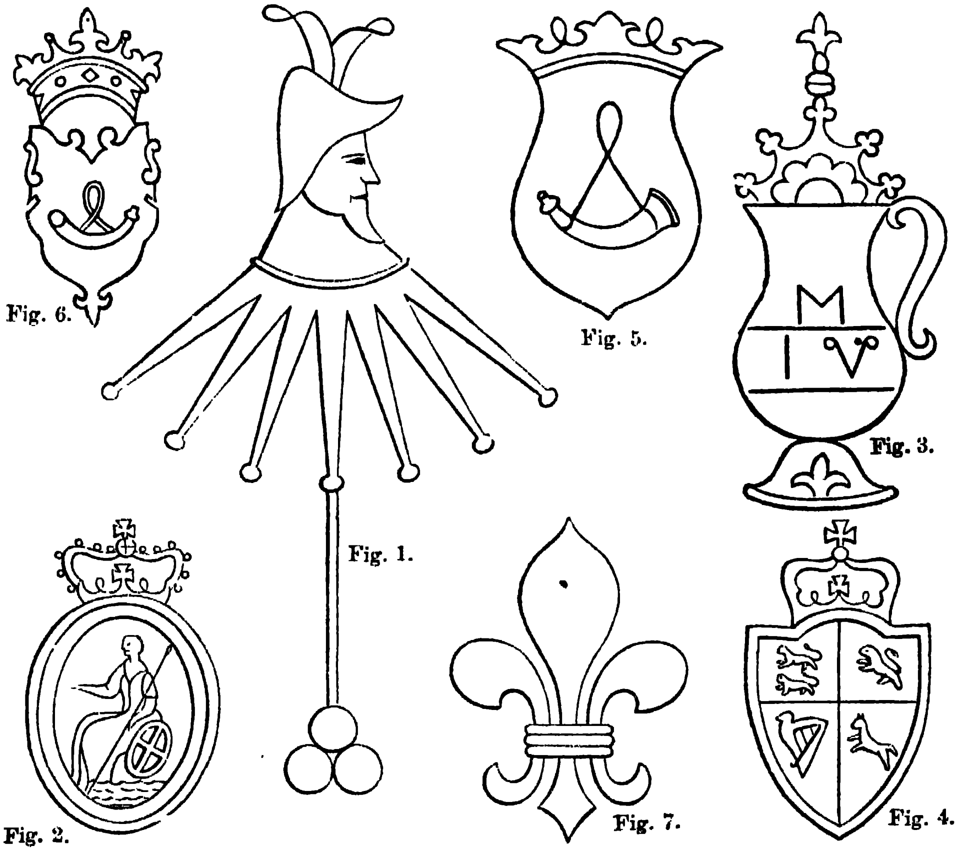
Fig. 6. Fig. 1. Fig. 5. Fig. 3. Fig. 2. Fig. 7. Fig. 4.

WATERMARKS USED IN THE MANUFACTURE OF PAPER.
Fig. 1.—Old Foolscap Mark. Fig. 2.—Modern Foolscap Mark. Fig. 3.—Old Pott Mark. Fig. 4.—Modern Pott Mark. Fig. 5.—Old Post Mark. Fig. 6.—Modern Post Mark. Fig. 7.—Mark for large-sized Papers.

The next operation is that of sizing, and for hand-made papers animal size is always used. The size is prepared and put into a vat, and the sheets are passed through one by one. The superfluous size is allowed to run off, and after a third pressing to secure the regular distribution of the size, the sheets are hung up on wooden laths or strings in a loft, the sides of which are formed of louvred windows, admitting a free current of air to the sheets. By this slow method of drying the sheets contract very considerably, and the fibres become much more firmly matted together, and a much stronger paper is the result. Papers made by machine may also be sized in this way after they are cut, or the sizing may be effected by suitable machinery carrying the sheets through the size, and then they may be dried in the air in the same way, when excellent strong papers, rivalling hand-made papers, are the result; indeed, the process of paper-making by hand is threatened with extinction, so closely do some machine-made papers, sized in this way, approach them in the properties of strength and toughness.

Papers dried in this manner are very rough, and require surface and finish. This is obtained by placing them between heated copper or zinc plates, and passing a pile of these several times through a pair of rollers with a considerable amount of pressure. Most machine-made writing-papers are also subjected to this process, called plate-glazing, the finish given by the calendering apparatus in the machine not being sufficient for fine papers. A very beautiful finish can be given to papers in this way by passing them through the rollers a considerable number of times, each operation improving the surface, until the sheets may be made to resemble polished plates of ivory.

The cutting of machine-made papers may be effected either by an apparatus at the end of the machine, cutting the single sheet of paper as it is made, or if the paper is reeled on wooden rollers, these may be carried to a detached cutting-machine, and several reels may there be cut at once. Up to a very few years ago all papers were cut in single sheets at the end of the machine, and where a high speed is not attained, this is an easy task, but as machines are run at a higher speed this has become more difficult, and combined with the application of the provisions of the Factory Act to paper-mills restricting the hours of boy labour, has caused the introduction of detached cutting-machines in most mills, as the produce of a machine during twenty-four hours can be cut by this means within ten hours. The process of cutting usually involves two operations. As the paper is made wider than is required, it is necessary first to cut it into strips of the proper width, and these again require cutting across into single sheets; but the same kind of cut will not serve for both operations. For the cross cut, a knife revolving at a certain speed cuts the sheet in two, but as the length of the sheet is continuous, so the action required for the longitudinal cut is continuous, and it is obtained by two circular discs of steel with a cutting edge working against each other, like the two blades of a pair of scissors. In the most improved form of paper-cutter the reels are attached to an iron frame-work at the back of the machine, and the sheets from each reel are passed between rollers to bring them together, and then brought between a pair of small feed rollers to the pairs of cutting discs or knives. These are fastened by screws set at proper distances on shafts extending across the machine, which, being movable, can be regulated for any width of sheet. The is here cut into continuous strips of proper width, and these passing between another pair of rollers are fed on to a fixed knife extending across the whole width of the machine, and at regular intervals are cut into sheets by means of a knife fixed upon revolving wheels, the size of the sheet being determined by the speed of the revolving knife, and regulated either by means of cone pulleys or an expanding wheel.

Some thick papers, such as browns, etc., are glazed by an extra calendering apparatus in continuous rolls, instead of being plated in single sheets. When this is done, the sheets are cut as they are made at the machine into strips by means of a set of pairs of revolving discs, and these slips are reeled in the same way as the ordinary sheet. They are then taken and passed between calender-rollers, one of which, instead of being of polished metal, is of paper, fixed firmly and tightly to the roller of some considerable thickness, and turned up true and polished in a lathe. These rollers revolve at different and very high speeds, and as the sheet passes through, it attains a very fine polish, having been exposed to a certain amount of friction in the process. They are then cut into sheets at the detached cutting machine in the usual way.

The same method of cutting and reeling is employed in the making of wall-papers for staining, or long elephants, as they are technically termed. These, being required in continuous lengths for the staining process, are cut as they issue from the calenders at the end of the machine, but instead of being reeled on wooden rollers, as for the cutting machine, shells of paper or wood, of very little thickness, are used. These shells fit on to an iron bar or core, as many as are required, according to the width of the machine, and when full are taken off and at once packed. Similar rolls of paper are now required for newspapers printed on the Bullock machine, an American invention, in which the printing machine feeds itself from a continuous roll, and during the operation cuts the paper and delivers it in printed sheets of the proper size.

The paper is next carried to the "salle," as the finishing room in paper-mills is universally termed, and in this room it is sorted and packed ready for the market. The operation of sorting entirely depends upon the quality of the paper, and is performed by girls and women. A quantity of paper is taken from the heap and placed on a wooden bench, which usually runs round the room, and if coarse papers are being sorted, the end of the handful of paper is by a dexterous twist turned up, exposing a portion of each sheet; the "broken," that is, the torn sheets, are then picked out, and the paper turned round and the other end exposed, to see if any sheets are broken on that side. These being removed, the paper is then "jogged" until straight and even, put on one side, and another handful operated on in the same way. Fine papers are turned over sheet by sheet, and the finest qualities are divided into three parcels, only clean, perfect sheets being passed for good paper, those sheets which contain spots, or are otherwise imperfectly made, being likewise separated from the broken and called "retree." These are usually sold at a lower price than the good, whilst the broken is either returned to the beating engines, or sold at a considerably lower price. If the sheets are of large size, such as news, the broken is often cut down to smaller common printing sizes, and this is re-sorted, a considerable proportion of perfect sheets being found, whilst the cuttings and the broken of the smaller size may be again reduced to pulp.

The paper is then passed on to the finisher, who counts it into quires of twenty-four sheets, and folds it over into the ordinary folio sheet, a round piece of hard wood or ivory being used to press down the back of the sheet to make it lie flat. For convenience of printing, and to avoid the crease, which is often unsightly, many papers are now put up flat, being counted into reams after sorting, and at once packed up in wrappers. Most news is also required flat, a machine being used for wetting the paper, instead of the old method of dipping each quire by hand; but as the parcel would be inconveniently large, it is usual to reduce the bulk to one-third its full dimensions by folding the whole ream over one side into the middle, and the other over that without pressing down the back on either side; in this way the bale carries well, and opens quite flat for the wetting machine, and as no force has been used, the slight crease made by folding is pressed out while damp. The great majority of papers are, however, put up folded in quires of twenty-four sheets, and again in reams of twenty quires. In most writing papers an old custom prevails of making the outside quires of twenty sheets only, and these of retree or broken paper, so that the stationer in buying these papers only receives eighteen quires of good paper and two quires of inferior or even worthless paper, which are eight sheets short—a practice much to be deprecated, as a false representation of the quantity of paper sold, and one that will, we hope, soon be numbered with other bad customs of the past. Printings and wrapping papers are now very rarely retreed, but are made up in full reams of twenty perfect quires; indeed, printings are now very often put up in reams of 500, 506, and sometimes 516 sheets, the latter being called "perfect;" this is obviously advantageous, as printing orders are usually given by the thousand, and under the ordinary method a ream must be broken for every order. Retree papers are marked on the wrappers with the letter R or the sign X, and if folded in half-quires, the backs of each quire are placed alternately, whilst good papers are placed in alternate half-quires in the ream.

The kinds of paper manufactured in this country are very various, but may be divided into three classes—viz., writings, printings, and wrapping papers. Up to a very recent period writing papers were almost entirely confined to blue laid and wove, cream laid and wove, and yellow wove; of late years, however, yellow-laid machine papers have been largely made in imitation of hand-made account-book papers, which, though usually called blue laid, are by no means so deep in colour as the blue-laid machine papers, but of a similar shade to the yellow wove. Tinted or coloured writings in great variety are now largely made and used for various purposes besides correspondence, and especially for printing circulars, cheques, etc. Printing-papers are almost invariably made wove, except news, for which purpose laid papers are still often used. The variety of colours and qualities of printing papers is very great, especially since the introduction of the aniline colours, the pattern books of some makers of tissues—a very thin and fine printing—showing nearly a hundred different shades. Wrapping papers are of very various kinds and qualities, from the coarsest brown and purple papers, made from the refuse of the rag-merchant and the paper-maker, to the finer qualities of printings, which are now largely used for this purpose; the principal kinds are purple sugar papers, browns, cap papers, grey and white cartridges, and printings, in a series of qualities, sizes, and weights almost interminable; indeed, so great is the variety of these papers that they are now rarely kept by the stationer, but by a distinct class of tradesmen.

In the early days of paper-making every size and make of paper was distinguished by a separate and distinct "trade mark" in the shape of a watermark, and although this practice is not now adopted except by some makers or for special purposes, we can easily trace how the names now used for various sizes of paper have arisen from the watermarks formerly used by the makers of these papers. The common and well-known paper called foolscap, no doubt, derives its name from an old watermark representing the symbol of the court jester of ancient days, the cap and bells (Fig. 1). This, however, has long since been superseded by the well-known figure of Britannia in an oval design surmounted by a crown (Fig. 2), which is now almost universally used for foolscap papers. Another favourite design for a watermark (Fig. 3) probably gave rise to the term pott paper for a size a little smaller than foolscap, and which, though nearly an obsolete size, is still occasionally made with the watermark represented by Fig. 4. Post paper, no doubt, derives its name from the old post-horn, which still remains the watermark of this size of paper. When the General Post-office was established it was customary to blow a horn on the arrival and departure of the royal mails, and to this circumstance, no doubt, this watermark owes its origin. Fig. 5 represents the old post watermark, and Fig. 6 the one now used for this size of paper.

For the larger sizes of writing and account-book papers, the fleur-de-lis is used for a watermark, either plain as for copy (Fig. 7), or in an ornamental shield surmounted by a crown for the several larger sizes of demy, medium, super-royal, and imperial. These watermarks are, however, now very often either not used at all, or are superseded by the name of the manufacturer, which is often accompanied by the year in which the paper was made, or other words to denote the quality of the manufacture.

SANITARY ENGINEERING.—XVI.

DRAINAGE AND WATER-SUPPLY (*continued*).

In our last paper we gave a few particulars of the facilities available for the supply of small outlying villages and districts with a permanent supply of water, with some rough data as to consumption, outlay, etc. We now propose to deal with the same question as applicable to large towns, with some particular reference to London. As a matter of fact the present water-supply of London is almost entirely conducted on what is called the intermittent system—*i.e.*, the water is only laid on for a certain number of hours during the twenty-four; and this, of course, necessitates a provision in every house or place where water is required—the erection of a cistern which shall hold at the very least sufficient for the day's consumption. In many of the large northern towns the supply is what is called constant—*i.e.*, the water is always flowing day and night; consequently, no cisterns are necessary, but a different class of fittings are required. In various towns the consumption of water per head per day varies very considerably, and is dependent upon local circumstances. In Glasgow, for instance, the supply is brought from a distance and unlimited, and the authorities encourage, from a sanitary point of view, what would elsewhere be considered as a waste of water. As a result, the consumption reaches about sixty gallons per head per day, and we may here remark that this, of course, includes all the supply required for manufacturing purposes—an element which in all large towns represents a quantity equal, if not greater, than that required for household and sanitary purposes. In Manchester, where there is a supply of water on the constant system, but not the same unlimited resources as to quantity, very strict regulations to prevent waste are enforced, and under these the minimum consumption is twenty-one gallons per head per day.

To give an idea of the quantity required on the constant system, when there is no water required for manufacturing purposes, but only for household supply, we may quote a case of 500 small houses in Brighton, in which the actual consumption was found to be eleven gallons per head per day. London is partitioned out into districts among various companies —the New River Company, the East London Company, the Southwark and Vauxhall, the West Middlesex, Lambeth, Kent, Chelsea, Grand Junction, etc. Consumption varies materially in different districts, but it may be generally stated at between twenty and thirty gallons per day per head.

Legislation has recently been busy with the subject of securing a constant supply, which is much to be desired from a sanitary point of view, as in crowded districts, low neighbourhoods, and poor localities the arrangements for the necessary storage are frequently insufficient, and the health of the inhabitants suffers accordingly, especially in case of epidemics. We often hear also of a deficient supply of water in cases of fire in certain districts, and of delay in getting the water turned on: these difficulties are obviated by the system of constant supply. There is, no doubt, a general tendency in this direction, opposed, however, by the vested interests and conservatism of the water companies, who have at present (1872) in London the monopoly, though the mass of legislation upon the subject is very considerable; yet a little inquiry shows very clearly that especially upon the points of rating and charges we are practically in the hands of the companies. As the constant supply is gradually introduced, district by district, as will probably be the case if the Metropolis Water Bill of last session comes fairly into play, a very general change will be requisite throughout the plumbing appliances of the metropolis, a stronger class of taps, pipes, etc., being required to meet the increased pressure necessary for a constant supply, the majority of existing cisterns being rendered useless; while in places where the supply is now insufficient, the health, cleanliness, and comfort of the inhabitants would be considerably increased.

Another advantage of the constant supply is well known: in the northern towns it constitutes a handy motive power always at command, and the following are the data for calculation. We may take the average head of water of an ordinary company at about 100 feet. Water, as is well known, weighs about 62 lbs. to the cubic foot. We have, therefore, always at command a power representing a pressure of about 50 lbs. to the square inch. In Halifax, Bradford, and Leeds this power is constantly applied to presses, lifts, and small machines of all descriptions. In this respect London is far behind: the companies refuse in all cases to supply water direct from the main, but compel the introduction of a cistern; this neutralises, of course, the company's pressure as a motive power: as if, for instance, it is required to fit up an hydraulic lift, the head of water required to work it—say 50 to 80 feet—must be obtained from a cistern specially constructed for the purpose, with its separate service-pipe; all this outlay being, as we may say, arbitrary, as in the North it is not required. There the companies protect themselves by the common-sense plan of supplying water by meter; and these applications of water-power to mechanical purposes largely increase the demand for water, and therefore not only benefit the company, but by adding to the body of pure water passing through the drains are, as far as they go, an assistance to the sanitary condition of the town.

The principle adopted in this and many similar instances by the London companies must be false commercially, as the result is to limit the sale of water, the article in which they deal, and to curtail the amount that passes through the system of drainage generally. In the course of the next few years, however, we may look for some improvement in this respect. The system of consuming water by meter is all but unknown in London, while, strange to say, it is universally adopted with regard to gas, though this latter is far the more difficult to measure of the two, almost the only meters at work in the London districts being those used by the companies themselves.

It might possibly be supposed that there existed some mechanical difficulty in the measurement of water, but that is by no means the case. In an earlier part of this series (No. VII., under the head of "gas-meters") we gave an account of the various methods adopted for the measurement of gas, and in the case of water there is much less difficulty, as there is not the liability to vary from changes of atmospheric pressure. The motive power is the *pressure* of the supply. In this case the weight of the head of water, whatever it may be, can always be made to register the quantity supplied, and the cost of the machine need not necessarily be more than that of an ordinary gas-meter. One very good arrangement, called Kennedy's—and we believe the subject of a patent—has a piston which travels up and down in a cylinder of accurately ascertained dimensions: by an ingenious reciprocating arrangement the water is admitted alternately above and below the piston, and the rod above communicates a rotary motion to an arrangement of clockwork in a separate chamber out of the water, so that the number of gallons of water that pass through the meter is shown upon small white discs with black indicators, exactly similar to those we are already familiar with in gas-meters of various descriptions. There is no real reason why throughout London all water should not be bought and paid for by meter when required in such quantities for manufacturing purposes as to make it worth while; the only reason why it is not so is that the companies' arrangements are not made with that view, and consequently any inquiry for a large supply of water is met by a demand which almost invariably makes it better worth while to sink a well and even erect special pumping machinery than to pay the companies' charges.

As we before remarked, if the supply of London was ample and constant, the additional amount of pure water discharged through the drains would materially assist in their cleansing, as in all systems except the earth system systematic flushing is a most important element in the efficiency of a system of drainage, especially if it be adopted on the wholesale principle above mentioned as in use in Glasgow, for we may here note that in that city more than 100 per cent. in its rate of consumption only represents the waste water that is allowed to run away down the drains.

In localities differently situated, and not supplied from an inexhaustible natural head of water, but where every gallon of water used has to be raised either into an artificial reservoir or perhaps through a lofty syphon, a system of waste of this character would entail upon the water company an outlay at least twice as large as was really necessary, as the expense of raising the extra supply, as we may call it, must be paid for by the public somehow or other. Here, then, an altogether different set of motives come into play, and it becomes an object so to arrange the details of supply that while there is amply sufficient for all necessary and sanitary purposes, no outlay should be incurred for raising water to be allowed to run away in waste. A glance at our last paper (p. 116), which explains the general methods for water-supply in limited districts throughout the country, will readily convey the idea of how heavily such a course would press upon the ratepayers of a poor village.

It is necessary in these cases to exercise all possible care in the economising of the supply, and our next paper will deal with cisterns, flushing cisterns, and the various mechanical appliances available for this purpose. Having arrived at that stage of our subject when the water is *laid on* to the house, we next propose to consider the methods of storing and distribution internally—*i.e.*, within the walls of the dwelling-house or warehouse—noting the sanitary precautions to be taken, and the best mechanical appliances available for various purposes.

TECHNICAL DRAWING.—LIX.

GOTHIC STONEWORK.

THE PERPENDICULAR ENGLISH PERIOD.

In the latter part of the fourteenth century, and towards the close of the reign of Edward III., symptoms appeared of a transition from the perfect and symmetrical style then prevalent, to one which displayed more elaborate and much richer work than its precursor, but was wanting in that chaste and elegant yet simple effect for which the Decorated period stands unequalled.

This style, when fully developed, is characterised by the exuberance and redundancy of its ornaments. In early examples, this enrichment was not carried beyond bounds, but in later times it becomes excessive, as if the chief aim of the architects had been to employ as much time as possible in the decoration.

From this profuse ornamentation, and minuteness of its ornamental detail, this style has sometimes been called the *Florid* Gothic, but it is more generally known as Perpendicular, in consequence of the peculiar arrangement of the tracery in the window-heads, which forms a very marked characteristic of the style. The beautiful flowing contour and curvilinear lines of the tracery, which characterise the Decorated period, were now suppressed by mullions running straight up from the bottom to the top of the windows, and transoms crossing horizontally. There was, however, a horizontal as well as a vertical tendency, for we find the high-pitched roof flattened, the arches depressed, the drop, the four-centred, and sometimes square arches having been used.

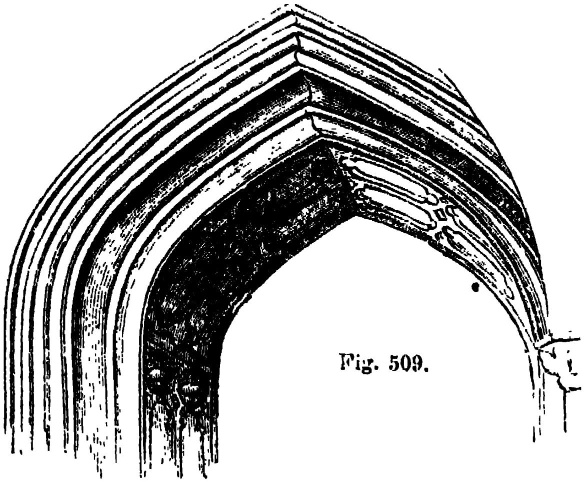
Fig. 509.

The arch, in fact, became more and more depressed, the mouldings more and more shallow and ineffective. The drop-arch is perhaps the most prevalent, but as the period advanced, an arch began to be used which is not to be found in any other. It is described, as a rule, from four centres (Fig. 441, Vol. III., p. 17), and is called the Tudor arch. It occurs in every variety which the form is capable of taking. As a general rule, the centres of the upper portions of the arch lie immediately below those of the lower, but this is by no means universal. Sometimes the whole of the upper portion uniting the arcs of the ends is struck from one centre, in which case, of course, the arch becomes a three-centred one (Fig. 440), being, in fact, half of an ellipse, or rather of a figure approximating to an ellipse, since no portion of a true ellipse is a part of a circle. Towards the close of the style the curvature of the upper portions is often found so slight that they can hardly be distinguished from straight lines, and in many instances, as the debasement of the style progressed, they were really straight. Ogee arches are of universal occurrence in the style, and foiled arches are very frequent. When the Tudor arch was not used, we generally find the low drop arch. Other forms were employed, but of small size, and in combinations of window-tracery and panelling.

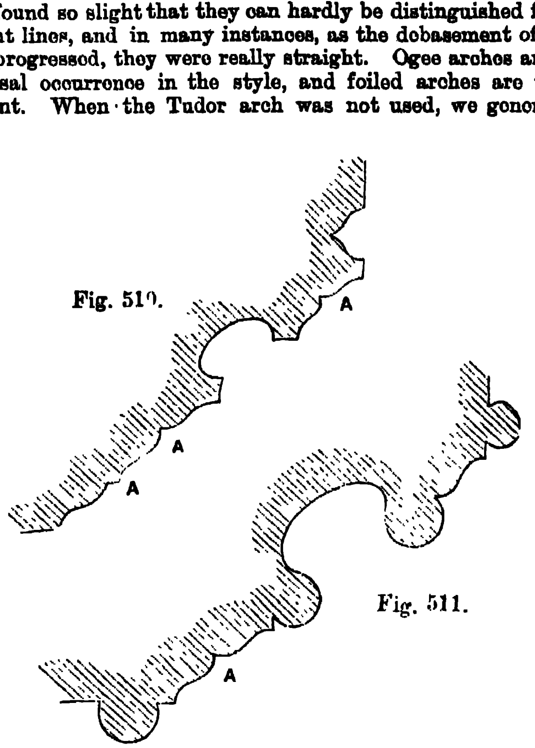

Fig. 510.
Fig. 511.

Fig. 509 is an arch from the south aisle of Chester Cathedral. The mouldings of this are continuous, and the soffit, or under surface of the arch, is panelled—both important features in Perpendicular arches.

The mouldings of this period are essentially different from those which preceded them, and have a character peculiarly their own. As a general rule, they are cut on a slanting or chamfer plane, and the groups of mouldings are separated by a shallow oval-shaped hollow, entirely different from those of the last period.

Fig. 510 is the moulding of the inner and Fig. 511 of the outer doorway of the south-west porch of Chester Cathedral. In each of these the shallow elliptical hollow is very conspicuous. The edges of this hollow were frequently rounded off into two small shafts, as in Fig. 511. The double ogee, or brace moulding, is seen at A, in each of the above examples.

The doorways of the early portion of this period had two-centred arches, but the characteristic form is the four-centred, enclosed in a square head, formed by the outer mouldings with a hood-mould of the same shape, the spandrils being filled with quatrefoils, flambeaux, roses, shields, etc. This square head is not always used inside the doorways, for an ogee canopy is sometimes substituted, or panelling is carried down to the arch, and there are also some small exterior doorways without the square head. Double doorways are not frequently used in this style.

The doors themselves were often covered with panel-work of a rich description, and sometimes with tracery in the head. This will be described in future papers devoted to Gothic woodwork.

PERPENDICULAR ENGLISH WINDOWS.

The general characteristics of the windows of this period—namely, the perpendicular mullions, and the horizontal transoms—have already been alluded to. The heads of the windows, instead of being filled with flowing ramifications, have slender mullions running from the heads of the lights between each mullion, and these have smaller transoms, until the window becomes divided into a series of small panels, and the heads of these being arched, are trefoiled or cinquefoiled. In the later windows of this style, the transoms are often furnished at the top with a small ornamental battlement, and the mullions present a concave outline. It is believed that fully half of all the remaining Gothic windows in the kingdom are of this period. The large east window of York Cathedral is admitted to be the finest specimen. The example here given (Fig. 512) is from the north aisle of Northfleet Church, Kent, and is chosen as illustrating most of the features described, whilst its simplicity will enable the student to copy it without much difficulty, although for his better guidance we may as well call his attention to marks in the illustration which serve to denote the centres from which many of the arcs employed in the construction of the window must be struck.

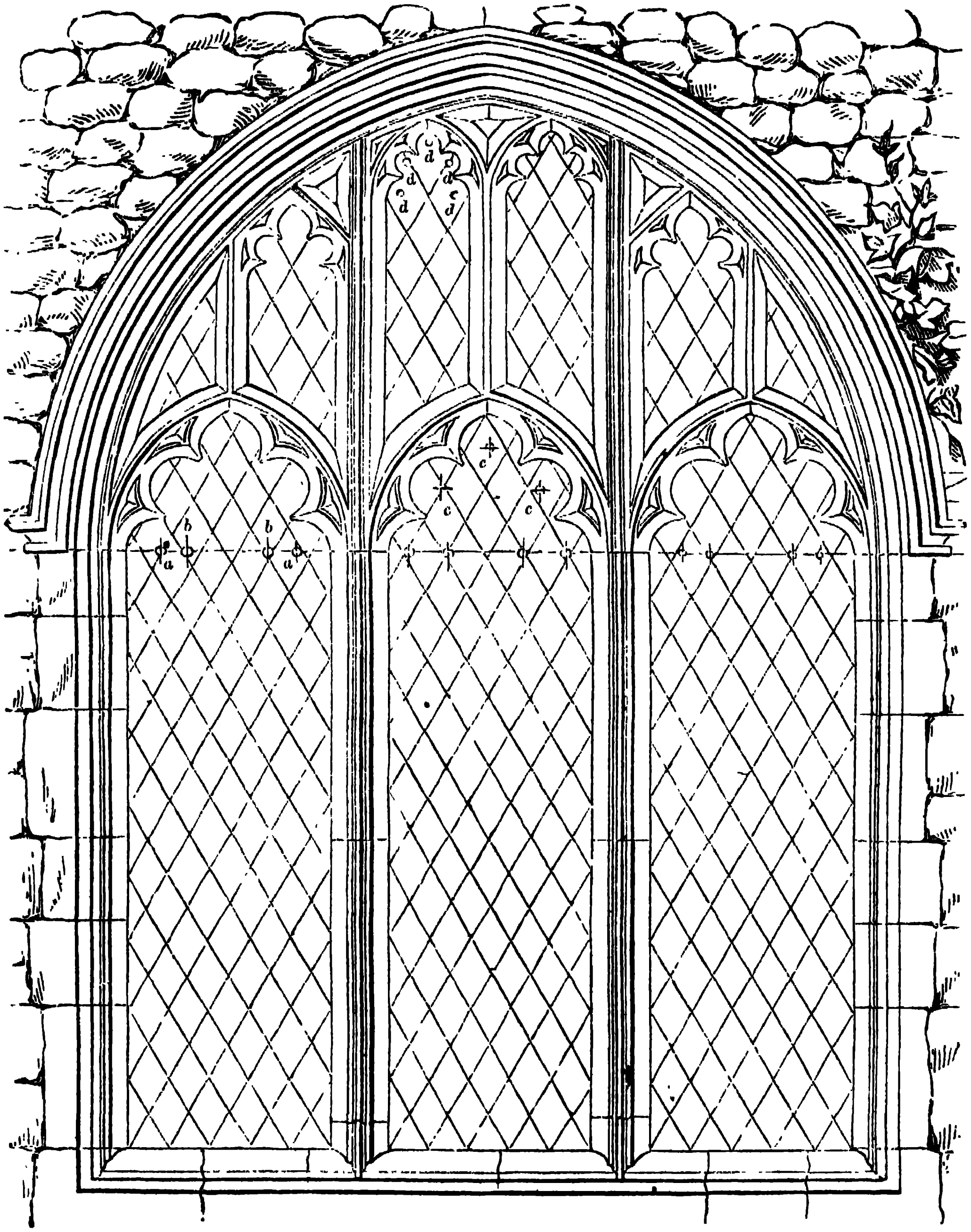

Fig. 512.—WINDOW FROM NORTH AISLE OF NORTHFLEET CHURCH, KENT.

Thus in the large pointed light in the bottom of the window on the left-hand side are shown the centres *a*, *a*, from which the arcs that form the lower part of the lowest cusp on either side are struck, and the centres *b*, *b*, from which are described the arcs that form the pointed head of the light itself, from the apex of which another short slight mullion rises. These centres are repeated in the lower light on the right-hand side of the window, as well as in the light in the centre; but in this are shown at *c*, *c*, *c*, the centres from which the arcs that form the remaining cusps are struck. In the small light on the left-hand side in the upper part of the central compartment between the principal mullions are shown at *d*, *d*, *d*, *d*, *d*, the arcs from which are struck the arcs forming the cusps in the heading of this small light.

CHEMISTRY OF THE FINE ARTS.—V.

By Professor CHURCH, Royal Agricultural College, Cirencester.

WATER-COLOUR AND TEMPERA PAINTING—FRESCO—SILICEOUS PAINTING.

AFTER the full details already given as to the nature of the materials employed in painting, it will not be necessary to treat the chemistry of the various processes in which they are used at any very great length.

Beginning with that method of painting which involves the least complication in the process of carrying it out, we may say a few words on water-colours. Here the finely-ground pigments mixed with small quantities of gum, sugar, etc., are merely spread over the surface of prepared paper or ivory. The binding material mixed with the colours prevents any particle from being subsequently removed by friction from the painted surface, but of course water destroys any work executed by this method, the binding material being dissolved, and no parts of the colour remaining but such as have sunk into hollows of the painted surface, or actually soaked into and stained it. In like manner water-colour drawings do not resist the injurious influences of sulphuretted hydrogen and of other gases. The minute protective film of gum which surrounds each particle of pigment is so far from being repellent of moisture that it actually absorbs it freely, charged as it may be with all sorts of dissolved impurities. Water-colour painting, then, offers but little chemical or mechanical advantage, so far as the preservation of the pigments against injurious influences is concerned. Nor must we omit to notice another source of weakness in this process—namely, the quality of the paper, vellum, or other material used as a surface for the reception of the colour. This material must be pure and strong, and free from the china-clay, pipe-clay, whiting, or plaster of Paris so largely used now to give weight and body to inferior papers. The less ash it yields when a trial piece is burnt, the better; many of the best sorts do not yield five parts in a thousand of ash. Nor should there be any specks of metallic iron from the machinery used in the manufacture, for these fragments will rust and discolour the paper round them with iron-mould stains. But the worst impurity in paper is a residual trace of the chloride of lime employed to bleach the pulp. This will destroy or injure most of the lighter tones of the pigments used. The purer the pulp, and the higher the quality of the rags used, the better will the paper be as to strength and as to freedom from excessive hygroscopic changes. Paintings executed in the older system of water-colour painting, as practised after the middle of the last century, were, for a long time at all events, merely tinted or stained paper. But with the progressive improvement of this branch of art by Turner and his contemporaries, there came also a wonderful development of the quality and richness of the pigments placed at the disposal of water-colourists. And within the last twenty years or so the practice of this branch of art has further changed by the gradually increasing use of opaque or body-colours. These are employed as freely as in oil-painting, though it is a question how far their use should be carried. For after all you cannot glaze over opaque white with clear tones in water-colour as you can do with such success in oil; so that the two methods of painting cannot really be assimilated in this important particular, while the loading of opaque colour in water-colour painting renders the work more liable to injury. It must not be supposed, from what we have said above, that the use of water-colours is of recent date. English artists painted with transparent colours and gum on linen cloth, at least as early as the fourteenth century; while the use of honey as a medium for the colours can also be traced back to mediæval times. But as we have said, in speaking of honey, its use is dangerous, owing to its absorbent power for water, and liability to change.

Before dismissing the subject of painting in water-colours, we may properly refer to the plans in use for preventing the greasiness of surface which paper and other materials so often present. Ox-gall would be a very unobjectionable material, were its colour less decided. Solutions of carbonate of soda, of borax, and of ammonia have been employed with a similar intention. The last-named compound seems to present some advantages over the others.

Tempera painting, or distemper painting, is by no means so simple a process, from a chemical point of view, as that just described. Not only does it demand the use of a prepared ground, but it involves rapid work, and sometimes requires subsequent treatment of the painted surface. Although in its widest sense tempera meant any more or less fluid medium with which pigments might be mixed, the term was generally employed in connection with the use of yolk and white of egg and parchment size. The process is a very ancient one, being mentioned even by Pliny; but in a damp climate and impure atmosphere cannot be regarded as satisfactory. The egg preparations were sometimes mixed with the milky juice (*latex*) of the fig-tree, sometimes with vinegar, wine, or honey. When size was employed, as in inferior works, it was prepared from washed parchment cuttings. The grounds were prepared with plaster of Paris, or size and whiting; upon these grounds the tempera colours were laid, while the finished painting was often finally saturated, in some parts at least, with boiled oil, or other kinds of varnish. Various contrivances were likewise adopted, especially in mural works, to secure the paintings from injuries arising from dampness or cracks in the walls or panels which were thus decorated. Linen, parchment, leather, and even leaves were often used for this purpose, being glued to the wall, and then covered with a coat of plaster or *gesso*, which was then saturated with warm parchment size, and thus made ready for painting. The generally unprotected condition of the pigments in true tempera pictures, the perishable nature of size and egg albumen, and the presence of sulphur in these organic substances, are the chief drawbacks in the use of this process.

Fresco.—This method of painting demands experience, and great technical as well as artistic skill. The particles of pigment are, it would seem, bound to the surface on which they are placed by a fine film of calcium carbonate (carbonate of lime), which forms upon them. A dry wall, pure sand and lime, both free from soluble saline matters, rapid work upon the fresh plaster, as well as a pure atmosphere, are among the chief conditions of permanence of works executed in fresco. There is, indeed, an inferior kind of fresco, called *fresco secco*, as distinguished from *buon fresco*, in which the wall plaster is allowed to dry, then rubbed down with pumice-stone, and moistened with lime-water just before commencing work. All the colours must be mixed with a little lime, prepared as described in Lesson IV. This method is adapted for ornamental or decorative rather than pictorial work, and under favourable conditions possesses some degree of permanence. Yet, compared with some of the other methods which remain to be considered, *fresco secco* cannot be regarded as of much importance.

In true fresco, or *buon fresco*, the following are the steps pursued:—Clean-washed quartz sand, as white, sharp, and uniform in grain as possible, is mixed with the old lime-putty described in our former lesson. The proportions used vary a good deal, but a usual mixture consists of two parts sand and one of lime. No plaster of Paris must be used in the preparation of this ground or *intonaco*. It must be laid upon a surface of tooled stone, brickwork, rough dry mortar, or roughened slate, previously moistened. An air-space behind the wall to be decorated is, where possible, a desirable precaution. It has been found that the sand may be omitted from the intonaco, if its place be supplied by crushed and sifted white marble, or even pumice. This substitution, however, may render the production of an even surface, to which an excess of lime has not been brought up by the float, somewhat difficult. Several coats of plaster are sometimes employed on the wall before the final one, which is prepared from day to day to receive portions of the design. The earliest and roughest coat may have small flint pebbles, etc., introduced into it without disadvantage. When the artist is prepared to begin work, the plasterer lays on a fine coat of intonaco, about one-eighth of an inch in thickness, upon that part only of the wall intended to be at once painted. Upon the wet, soft plaster the cartoon is laid, and the outlines and important details pounced in, or else indented into the plaster by means of a bone point. The artist then begins to paint, using hog's bristle and other hair brushes, bone or ivory palette knives, and palettes of sheet zinc. Tints, if much required, should be kept ready mixed, and may be preserved in earthenware pots, their exact tone when dry being ascertained by trying a little of each on a lump of dry umber or clay. It is impossible to describe in writing all those minute details of the practice of fresco which it is necessary to recognise in working. Success can only be secured by experience. Still it may be as well to note that the absorption of the moisture of the coloured tints by the ground has to be carefully watched. When this suction is too rapid the colours may very probably cease to become firmly adherent; a fine spray of lime-water, directed on to the part which has become too dry, has been found successful in remedying this accident. Before noting the pigments which may be safely employed in fresco, a word or two on the chemistry of the process may not be unadvisable. The gradual absorption of carbon dioxide or carbonic acid gas by part of the lime in the ground which has not before been carbonated, seems to be the only chemical action which takes place in a fresco painting. But the assertion has been often made and repeated that a calcium silicate (silicate of lime) is formed in the course of time by the reaction of the lime and the silica of the plaster, and that the hardness of old mortars and similar preparations is mainly due to this cause. This idea is scarcely supported by the intense hardness which mortars made of lime and non-siliceous substances often acquire, nor indeed by the analysis of the old Roman and mediæval mortars themselves. It is possible that traces of such a silicate may be found when slaked lime and sand containing soluble silica remain long in contact. But the absence of mutual decomposition in the case of mortars made of dissolved water-glass and calcium carbonate renders extremely improbable any distinct union of lime and silica in the case of the ordinary mixtures containing sand used in fresco. Mr. Barff, however, states[*] that "lime, in the presence of water, acts upon the sand, dissolves and unites with some of the silica of which the sand is composed, and so a silicate of lime is formed; and this silicate of lime forms, I believe, the binding power in mortar."

In speaking of the colours which may be safely used in fresco, we may cite one simple test to which it is easy to submit them. Let a mixture of any doubtful pigment and some strong lime-white be allowed to grow gradually dry on a piece of earthenware. Then moisten it once or twice, and see if its colour remains as at first. Some inadmissible pigments may stand this test, but it is clear that all colours which do not stand it should be at once rejected. Ochres, cadmium yellow, cobalt yellow, some varieties of vermilion, and all the iron reds, chromium oxides, Guignet's green, some cobalts and ultramarine blues, with a large number of mineral and carbonaceous browns and blacks, may be safely employed in fresco. Vegetable and animal colours, with the exception of one or two combinations of organic acids with lime or magnesia, such as the euxanthates and picrates of these bases, cannot be safely used.

Siliceous painting.—The only kind of siliceous painting which can be regarded as of real practical importance, is that invented by the late Prof. Fuchs, and largely used by other German artists. Stereochromy—for such is the name applied to this process—has undergone several modifications in details since its first introduction. In giving an account of this most valuable method of painting, we shall describe the various steps of that form of the process which has proved to be the most successful.

A dry ground, free from sulphates, whether soluble or insoluble, and from all soluble matters of other sorts, is a necessary preliminary to a stereochromic painting. Some cements, such as Portland and Roman, which contain sulphates, have been, however, recommended as ingredients in the mortar-ground. Rain does not injure a picture painted by this method, but damp from behind or soluble saline efflorescences will do so. The ground may be a mortared wall, a surface of terra-cotta, a slab of stone or slate, or such a surface as would be suitable for fresco. Such of these grounds as exhibit joints or irregularities may be rendered available for use by means of a kind of cement or intonaco, which is made by mixing precisely such sand and lime as are best adapted for securing the surface desired, which should not be too smooth or too dense. Three parts of fine sand to one of lime is found to be the best proportion generally for the intonaco, which should be one-eighth to one-tenth in thickness, and which may be laid upon a mortar or undercoat of coarser quality: two undercoats are often used. A ground containing more sand, half fine and half coarse, has been found to give good results. A water-glass cement may be used instead of these mortars. It may be made by mixing sand, lime, zinc-white, and water-glass together, and laying the mixture on as an intonaco. Or crushed marble or limestone, or, better still, dolomite, or indeed any rocky material adapted to take the place of the sand, may be used instead of it in this cement, provided it be reduced to a proper and uniform degree of fineness in grain. The water-glass used in preparing this cement is that variety known as double water-glass, containing both potash and soda. Its preparation has been given in the preceding lesson. Unlike the water-glass which has to be subsequently employed for fixing the finished picture, the water-glass used in the mortar need not be rendered alkaline by the addition of caustic potash or soda. It will be none the worse for the presence of an excess of silica, introduced by shaking up with the solution some gelatinous silica recently precipitated. If the ground thus prepared, or any of the other grounds just mentioned, are not absorbent enough, they may be improved in this respect by burning a little spirits of wine upon them, a very useful expedient, in dealing with damp or non-absorbent walls, in many processes of mural decoration. Another way of curing a too dense or non-absorbent surface is by washing it over with a weak solution of phosphoric acid, or of monocalcic phosphate (biphosphate of lime). The plan, however, of saturating either the wall itself, or any of the mortars or other grounds just named, with soluble silicates or water-glass, though formerly recommended, is not now practised by any of the great German authorities on this process. It is still more important that the final coat of fine mortar, rich in fine sand but containing very little lime, and perhaps about ten or fifteen per cent. of zinc-white, should not be saturated with water-glass before commencing actual work. We are aware that Professor Barff gives (1870) entirely different directions, stating that both the under-ground and that which has to receive the painting must be saturated with soluble silicate. This, however, is a plan which the best stereochromic artists have long ago abandoned.

When the surface is dry it is prepared for work by moistening it with distilled water, or with lime-water, if the mortar has been spread some time, otherwise a solution of ammonium carbonate may be used. Then the colours, mixed either with distilled water, lime-water, or baryta-water, and containing, whenever possible, a little zinc-white, are laid on in the manner of fresco painting. Evenness of distribution is a great point here; the colours should not be loaded or laid on with an excessive impasto. White draperies may be painted in zinc-white, the only white admissible, or the ground may be left. Cross-hatchings are allowable, yet all the work should be done as much as possible before any part of the picture is submitted to the fixing process. The use of lime-water with the colours, and in wetting the wall, enables touches to be put in one upon the other without disturbing the paint already laid on. The fixing is performed with a syringe with cross jets, or with an apparatus in which a spray is produced by the violent commingling of air and water-glass solution. We have found that the little instrument called "l'odorateur," or "la bouffée," is admirably adapted to the work of distributing the fixing liquid upon the painted surface without disturbing the colours. It should be connected by an india-rubber tube with the nozzle of a pair of bellows or a blowing machine, the tube of the instrument dipping into a vessel of the fixing liquid kept warm. The fixing liquid is the double water-glass before referred to, and described in Lesson IV., or else pure potash silicate; but before it is used for our present purpose it should be alkalised by adding to fourteen parts of it, of specific gravity 1·2, one part of pure caustic potash solution, of specific gravity 1·33. Previous to use this liquid may be diluted with from one-half to twice its bulk of distilled water. Repeated applications of a weak water-glass are better than fewer applications of a more concentrated liquor. The fixed surface, when dry, must not shine. The success of the fixing process may be ascertained by passing a dry white cloth, and then the same material wetted, over the painting. If a little colour comes off from the rough points, it is of no consequence; but if anything like a smear occurs, it shows that the fixing process must be repeated. It is an advantage to the finished painting to be once and again sponged with warm distilled water, any soluble salts which may effloresce on the surface being thus removed. There is, however, a siliceous bloom which sometimes appears on stereochromic pictures, and this no mechanical or chemical process can remove. It occurs when over-silicated water-glass is used. This hard white opaque film may, however, be rendered transparent by a process which the author of these papers used ten years ago for this purpose, namely, the application of a warm solution of copal and paraffin to the clouded surface.

The colours used in stereochromy are used in fresco. Other colours also have been employed, both by English and German artists; a few pigments even of vegetable and animal origin having been found to possess an unexpected permanence.

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[*] *Journal Soc. Arts*, xix., p. 160.

PRACTICAL APPLICATION OF THE FINE ARTS.—VIII.

THE ART OF GLASS PAINTING.

By P. H. Delamotte, Professor of Drawing, King's College, London.

We again give two illustrations of various character, and somewhat advanced upon the previous designs. The one (Fig. 14) is a Pope in the attitude of blessing, and is in the *cinque-cento* style. It is impossible in a woodcut to give either the colours or even technical representations of colour which will be at all satisfactory. We will attempt, however, to describe the colours as they appear in the original sketch at the moment before the writer. The ornamental seat (except the cushion, which is red) and side ornaments are of a rather bright yellow, heightened by the stain and by shade to a deep orange in the ornamental parts, the plain surfaces remaining the original colour of the glass. The interiors of the arcade beneath the seat are of a bright emerald or malachite green, and have within them a second line parallel to the leading, which is not given in the cut. The *nimbus* or glory round the pontiff's head is of a very light bright yellow colour, shaded off in rays so as to look like a sun behind the head. This is effected by the stain. The deeper-coloured cross is of a rather light crimson ruby glass, a little lighter and rather less crimson than the cassock or under-garment, which, of course, is the striking colour of the whole window. As this latter is the colour to which all the rest has to lead up, it will be necessary to choose this first, and to make all the rest subservient to it. This being a flushed glass, it is easy to select such glass as will have considerable modifications of the ruby colour: thus the prominent knee on the right hand of the figure should be lighter, having a thinner coating of the flushing. The broad border and fringe will have to be of white glass for the sake of leaving the rows of pearls of that colour, but the whole of the rest will require the stain, as well as, of course, the shade in the necessary parts. The skirt below this, again, is also of rather thick white glass, which will only require delicate shading. This and the sleeves are supposed to be parts of the same garment, and are of the same colour, except the upper part of the left arm, which is the same light violet as the lining of the chasuble. This latter is of a deep gold tissue, and should be coloured accordingly, whilst the belt and brooch are supposed to be of pure gold, therefore of a brighter and clearer colour. Around and beneath the feet of the pontiff is the blue sky, and here again is room for the employment of taste in the choice of the blue. If it were possible to obtain some of the old twelfth-century blue, that naturally would be the colour to be desired, but failing this we must obtain the nearest approach to it that is possible. Of course in the sky we would not introduce more shade than is absolutely necessary: a little will be required, and this may lead off gradually towards the leading. If much is used it will take away greatly from the transparency which is so greatly to be aimed at. But what cannot so well be effected by shading may be partially brought about by a choice of uneven glass and glass of a different tone. The greater the irregularity the pleasanter will be the effect. It remains to mention the clouds at the bottom: these will be white, and rounded off by shading. The staff is white with golden ornaments.

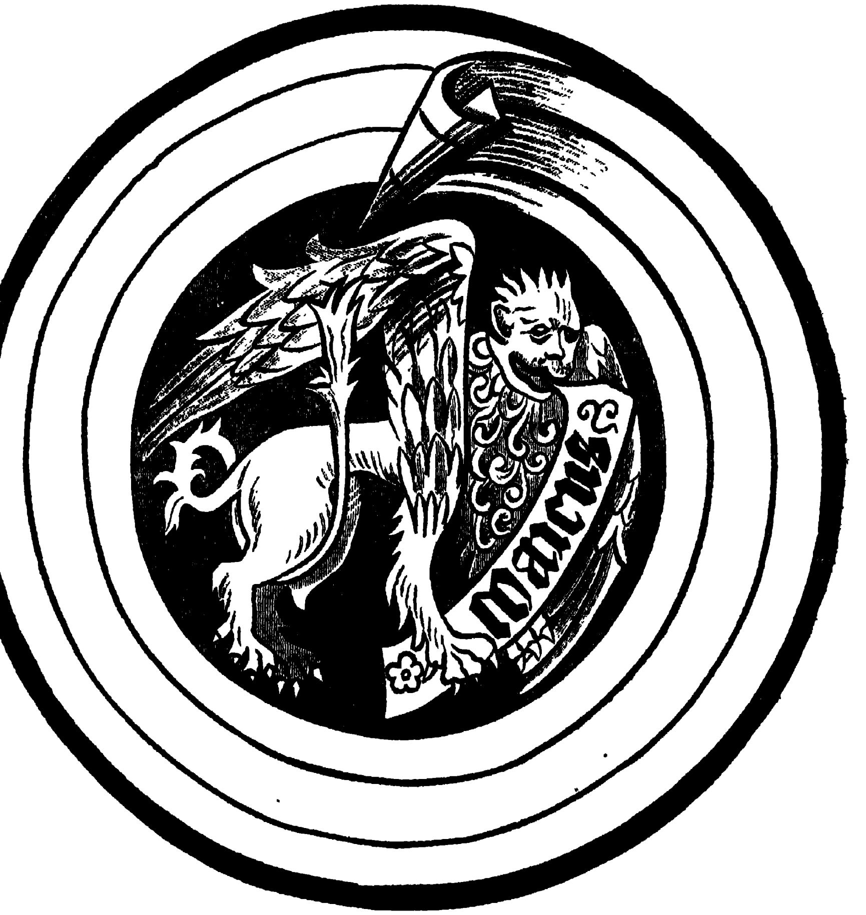


Fig. 15.—THE LION OF ST. MARK.

There is plenty of room for taste and ingenuity in the painting of this design. In the mere decorations much may be done with the stain in causing variety, and bringing forward the various ornamental parts. In the drapery, again, we have only slightly indicated the principal folds, which must be carried out and deepened by the artist. The folds and embroidery of the chasuble, also, require attention, and in these matters the enthusiastic operator will be distinguished from the mere workman. In the face, hands, and foot there is opportunity again for the display of the utmost skill. The original, as it lies before us, shines forth with a countenance of bland meekness and amiability, which it will tax the ingenuity of the most skilled art-workman to imitate; but these things should be attempted—it may not always be with success, but many failures make a success; and every head carefully and conscientiously worked out, and every hand or even foot drawn accurately from nature, or copied from a great master, brings with it the power of execution, and the knowledge of form and anatomy, that was impossible without such practice. It is perfectly certain that a man who slurs over hands or feet will never accomplish the more observed, though not more difficult, countenances which will convey expression, thought, and beauty. The hands, too, must be made to accord with the age and character of the figure. The young, plump hands of a girl will not fit themselves to the figure and countenance of an ecclesiastic, nor will the hands of a priest be adapted to the habit of a boy. The warrior, the scribe, the youth, and the old man ought as much to be detected in the hand as in the face.

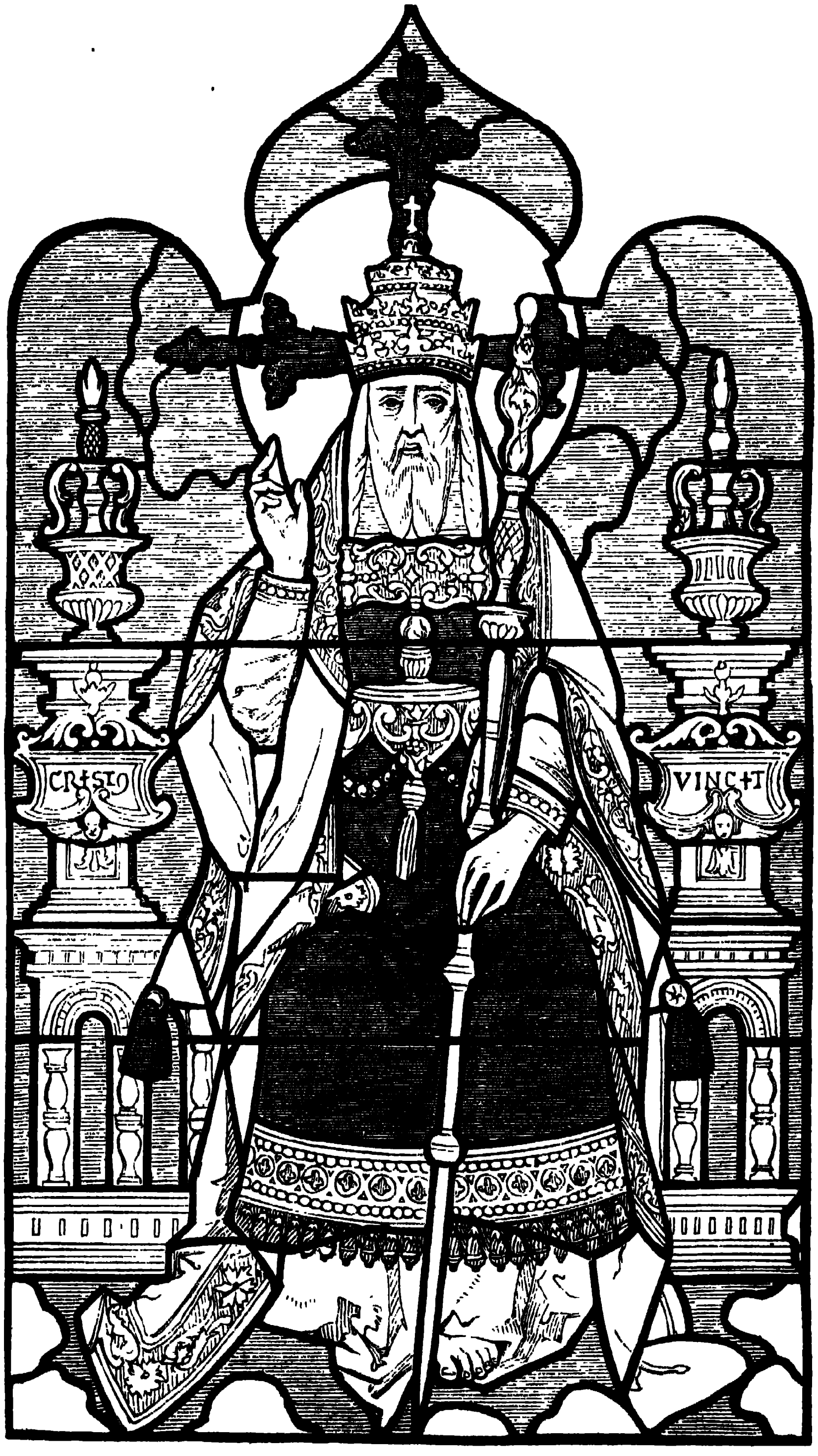


Fig. 14.—A POPE IN THE ACT OF BLESSING.—CINQUE-CENTO STYLE.

In our other diagram (Fig. 15), the Lion of St. Mark, we have rather a vehicle for a colour and a combination of agreeable lines, than either beauty of design or direct purpose of conveying ideas. There must be spots where the grotesque and colour, without ideas, is more suitable than more elaborate work. In this, too, will be found a lesson of ingenuity in placing the leads. It is possible to arrange the joinings in such a window as this that they do not in the slightest degree strike the eye; or, on the other hand, it is quite open to a misguided imitator of antiquity to avoid the natural divisions, and to insert just those which will most readily strike the beholder, we had well-nigh said, with horror and amazement. Deep primary colours will be found very suitable for the present design, as for instance a deep ruby ground, with a golden lion heightened with the stain in some places, a white or antique white (a greenish toned glass) label, with the lettering as black as possible, and a scroll pattern in brown, within concentric rings of a purplish white, a good blue and a white glass. A little shading may be introduced, but much would interfere with the transparency, which, however, would rather be heightened by a running line of scroll-work introduced with taste and elegance.

With these two examples we bring to a conclusion our Lessons in Glass Painting; we have endeavoured in the earlier chapters of the series to describe clearly and succinctly the various processes employed in the art, and our later lessons have been chiefly devoted to the practical application of the rules we have laid down. Of the importance of this branch of Art Manufacture it is hardly necessary to speak. Glass painting, which in this country had almost become a lost art, is now steadily reviving, and the workshops of many of our English manufacturers can show specimens which for correctness of drawing and beauty of colour are no whit inferior to the finest examples of Continental art. The lessons on glass painting will be followed by a series on mosaic work.

BUILDERS' QUANTITIES AND MEASUREMENTS.—VII.

BY E. WYNDHAM TARN, M.A.

We shall now exemplify the foregoing rules by giving an imaginary dimension book and abstract, the quantities of which will hereafter appear in the general bill. In taking out quantities or measuring from the building, surveyors generally abbreviate several of the terms which have to be frequently repeated; thus, P. W. is put for "plain work," S. W. for "sunk work," M. W. for "moulded work," C. W. for "circular work," C. S. W. fo~ "circular sunk work," C. M. W. for "circular moulded work," and so forth.

KENTISH RAG STONE.

	50 0 26 6	1325 0	24 inch rough random walling.
6)	6 6 3 6	136 6	Ddct.
		1188 6	
	50 0 26 6	1325 0	24 inch random coursed walling.
5)	6 6 3 6	113 9	Ddct.
	8 6 3 6	29 9	Ddct.
		143 6	
		1181 6	
2)	50 0 26 6	2650 0	Pointing in blue ash mortar.
11)	6 0 2 6	165 0	Ddct.
	8 0 2 6	20 0	Ddct.
		185 0	
		2465 0	
100)	2 0 1 3 0 9	187 6	C. bondstones.

PORTLAND STONE.

	30 0 26 6	795 0	4 inch ashlar facing.
6)	5 6 2 6	82 6	Ddct.
		712 6	
50)	2 4 1 6 1 0	175 0	C. bondstones.
15)	3 9 1 0 0 4	18 9	C. spandril steps.
15)	3 9 1 2	65 8	Half-sawing.
15)	3 9 1 7	39 1	P. W. to top and front.
15)	3 9 1 2	65 3	Add soffit.
15)	3 9 0 4	18 9	S. W. to rebate.
15)	3 9	56 3	Chamfer 2 inch wide.

No. 30 holes drilled for balusters.

" 15 cutting and pinning ends of steps into wall.

2)	5 9 1 6 0 5	7 2	C. winders.
2)	5 9 1 9	20 2	Half-sawing.
2)	5 9 1 6	17 3	P. W. top and front.
2)	5 9 1 9	20 2	C. S. W. soffit.

No. 2 ends cut and pinned into wall.

	3 9 3 9 0 7	8 4	C. landing.
	3 9 3 9	14 1	P. W. to top and bottom.
	3 9 0 7	2 2	Add front.
	7 6	7 6	Cutting and pinning in wall.
	15 6 3 0	46 6	3 inch balcony.
	15 6 6 0	93 0	P. W. top and bottom.
	22 0 0 5	9 2	M. W. front and ends.
	22 0	22 0	Throating.
	6 0	6 0	Joggled joint to 3 inch landing.
5)	4 4 1 0 0 6	10 10	C. sills.
5)	4 4 1 0	21 8	Plain bed.
5)	4 4 1 5	30 8	P. W. top, front, and projection.
5)	3 6 0 7	10 [illegible]	S. W. top.
5)	4 4	21 8	Throating.
	33 0 3 0 1 3	123 9	C. cornice.
	33 0 1 3	41 3	Half-sawing.

2)	30 0 1 6	90 0	Plain bed.
10)	3 0 1 3	37 6	Add joints.
	36 0 1 6	54 0	S. W. top.
	39 0 2 3	87 9	M. W. front.

No. 4 mitres to cornice, 2 ft. 3 in. girt.
„ 2 stopped ends to ditto.
„ 10 plugs, 10 lbs. lead.

10)	0 7	5 10	Groove for lead.
	30 0 2 0 0 9	45 0	C. blocking.
	30 0 2 0	60 0	Half-sawing.
	31 6 2 0	63 0	P. W.
	30 0 0 9	22 6	Add.
10)	1 0	10 0	Groove for lead.

No. 10 plugs, 10 lbs. lead.
„ 20 slate dowels in cement.

2)	7 6 1 1 1 1	17 7	C. columns.
2)	1 1 1 1	2 4	Plain bed.
2)	7 6 3 3	48 9	C. S. W.
4)	3 3 0 6	6 6	Add.
2)	2 0 1 9 1 9	12 3	C. capitals.
4)	1 9 1 9	12 3	Plain beds.

No. 2 carved capitals to design.

2)	1 0 1 6 1 6	4 6	C. bases.
4)	1 6 1 6	9 0	Plain bed.
2)	3 6 0 9	5 3	C. M. W.
2)	6 0 0 3	3 0	P. W.

No. 10 slate dowels in cement. 20 mortice holes.

7)	1 7 1 6 1 1	18 3	C. voussoir to arch.
7)	1 7 1 1	12 0	Plain bed.
7)	1 7 1 2	12 11	S. W. bed.
7)	1 6 1 3	13 1	C. W. soffit.
7)	1 3 0 9	6 7	C. M. W.
6)	6 6	39 0	Lintels, 9 in. × 9 in.
6)	6 6 0 9	29 3	Plain bed.
6)	6 6 1 6	58 6	P. W.
6)	4 6	27 0	Chamfer.
	25 0 1 6 0 6	18 9	C. coping.
	25 0 1 6	37 6	Plain bed.
8)	1 6 0 6	6 0	Add joints.
	25 0 1 6	37 6	S. W. top.
	25 0 1 0	25 0	P. W. front.
2)	1 6 0 6	1 6	Add ends.
	53 0	53 0	Throating.
8)	0 3	2 0	Groove for lead.

No. 8 plugs, 4 lbs. lead.

50)	3 1 1 10 1 1	305 10	C. quoins.
50)	3 0 1 9	262 6	Plain bed.
50)	1 9 1 1	94 10	Add joints.
50)	4 6 1 0	225 0	P. W. front.
50)	11 0 0 6	275 0	M. W.

YORK STONE.

6)	4 4	26 0	3 in. weathered, throated, and tooled sill, 9 in. wide.
			No. 12 fair ends to ditto.
	51 0	51 0	3 in. tooled coping, 12 in. wide, weathered and throated.
			No. 2 fair ends to ditto.
	4 6 2 6	11 3	7 in. sink.
			No. 1 rounded corner to ditto. „ 1 rebated hole to ditto.
4)	1 6 1 6	9 0	3 in. template.
	22 0 2 3	49 6	3 in. core for cornice.
6)	3 6 1 6	31 6	3 in. rubbed hearths.
	12 0 9 6	114 0	2½ paving.
	43 0	43 0	Cutting edge to ditto.

PAVING.

	30 0 12 6	375 0	Elland edge sets in sand, and grouted.
	30 0	30 0	Granite curb 12 × 6.

MARBLE.

4)	3 6 1 6	21 0	2 in. polished slabs to fire-places.
2)	13 0 0 7	15 2	1 in. mantel, jambs, and shelf.

No. 4 console chimney pieces, value 10 gs., P. C.

ABSTRACT.

Kentish Rag.	Portland Stone.					York stone.		Paving.	Marble.
Cube bond.	Cube.	Superf.		Run.	Nos.	Superf.	Runs.	Superf.	Superf.
ft. 187 6 Superf. 24 in. rough random walling. 9)1188 6 132 yds. 24 in. coursed walling. 9)1181 6 131¼ yds. Pointing in blue ash mortar. 9)2465 274 yds.	ft. 175 0 18 9 7 2 10 10 123 9 45 0 17 7 12 3 4 6 18 3 18 9 305 10 757 8 Landing. ft. 8 4 Superf. 4 in. ashlar ft. 712 6	Half Sawing. ft. 65 8 20 2 41 3 60 0 2)187 1 93 7 Plain bed. ft. 21 8 127 6 2 4 12 3 9 0 12 0 29 3 43 6 262 6 94 10 614 10 P. W. ft. 154 9 17 3 16 3 93 0 30 8 85 6 3 0 58 6 26 6 225 0 710 5	S. W. ft. 18 9 10 3 54 0 12 11 37 6 133 5 M. W. ft. 9 2 87 9 275 0 371 11 C. W. ft. 13 1 C. S. W. ft. 20 2 55 3 75 5 C. M. W. ft. 5 3 6 7 11 10 3 in. balcony. ft. 46 6	Lintels 9″ × 9″, in lengths of 6 ft. 6 in. ft. 39 0 Groove for lead. ft. 5 10 10 0 2 0 17 10 Chamfer. ft. 56 3 27 0 83 3 Cutting and pinning to landing. ft. 7 6 Throating. ft. 22 0 21 8 53 0 96 8 Joggle to 3 in. landing. ft. 6 0	Carved capitals to design. 2 Mortice holes. 20 Holes for balusters. 30 Cutting and pinning ends of stops. 15 2 17 Mitres to cornice, 27 in. girt. 4 Stopped ends to ditto. 2 Plugs. 10 10 8 28 Slate dowels in cement. 20 10 30 Lead. lbs. 10 10 4 24	7 in. sink. ft. 11 3 3 in. rough in templates, etc. ft. 49 6 9 0 58 6 3 in. rubbed hearth. 31 6 2½ paving. ft. 9)114 0 12¾ yds.	3 in. sill, 9 in. wide, weathered and throated. ft. 26 0 3 in. coping, 12 in. wide, ditto. ft. 51 0 Cutting edge of paving. ft. 43 0 Nos. Fair ends to sills. 12 Fair ends to coping. 2 Rounded corner to 7 in. sink. 1 Rebated hole to sink. 1	Elland edge sets in sand and grouted. ft. 9)375 0 41¾ yds. Run. Granite curb, 12 × 6. ft. 30 0	2 in. polished slabs. ft. 21 0 1 in. ditto. ft. 15 2 Nos. Console chimney-piece, 10 gs., P.C. 4

GREAT MANUFACTURES OF LITTLE THINGS.—VI.

BY CHARLES HIBBS.

NEEDLES.

A PLEASANT little country town on the borders of Worcestershire, situate in the midst of the finest scenery in the Midlands, is the present seat of the needle manufacture. Why it should have settled down in that precise spot, after migrating from place to place, with something of the aimlessness which characterises the wanderings of a tramp, it is not easy to explain. But whatever the cause, it cannot be otherwise than gratifying to find a thriving manufacturing community planted in the midst of corn-fields and cattle pastures, enjoying the benefits of pure air and ample space, instead of being crowded into an overpacked town, where breathing-room is an almost unattainable luxury. Redditch, which, according to the latest census, has about 7,000 inhabitants, all of whom depend, in some way or other, upon the needle manufacture, with the exception of some few who are engaged in the making of fish-hooks and pins, has established a reputation throughout the whole world, not inferior to that enjoyed by Sheffield and Manchester for their special productions. Though it has a half-rural population, not free from that bucolic fixity of idea which offers a passive resistance to progress, the improvements in the needle manufacture have quite kept pace, especially of late years, with the mechanical advances of the time. A Redditch needle, smooth, clear-eyed, gently tapering to a point of extreme fineness, possessing the happy medium of springiness and rigidity, and as straight as a Parthian arrow, is as near perfection as it is possible to be. The processes of its production, which we now proceed to describe, differ in many respects from those in use only a few years ago.

The steel wire of which needles are made is procured principally from Sheffield. That centripetal force which tends to concentrate the various factors of production into one spot is at work in the little town of Redditch, and there is some talk of a wire-mill being established, to render it independent of that source of supply. The wire comes in coils, and is first cut up into lengths sufficient for two needles. A strong pair of shears is fixed in an upright position, and the coil being slung on a hook to relieve the workman of its weight, is cut through, and afterwards fed up to the shears by his left hand, while his right holds the gauge which measures off the length. The handle of the shears is worked by his thigh. The wire is soft, and the shears will cut through 250 wires of medium gauge. These short pieces have then to be straightened, as each partakes of the curvature of the coil from which it has been cut. The method of doing this is curious. A number of pieces, say 20,000, are placed within two rings, which hoop them about half-way between the centre and the extremities. They are not packed tightly in these rings, but lie loosely, the space being about three-fourths filled. All is then heated to a dull red, and the rings being made to stand upright on a slab of iron, the straightener takes a bent steel bar by its two ends, and pressing heavily with it on the middle part of the wires, between two rings, rolls them over each other by a long sweep from side to side. When he has operated sufficiently on those at the top, he makes the rings roll on a little way, and another portion of the wires comes under the rubber. Thus he goes on, until every individual wire is perfectly straight. The next operation is to point them. The former method of doing this was very similar to the old process of pointing pins, described in our last article. The workman sat before a dry grindstone revolving at high speed, holding between the palms of his hands from fifty to a hundred needles, which he rolled backwards and forwards while he pressed their points upon the stone. It was a murderous occupation. The fine dust found its way to the delicate air-passages of the lungs, clogging them up; and was so deadly in its effects that no pointer could look forward to more than ten or fifteen years of life after he began to follow his trade. About twenty-five years ago, the use of the Sheffield grinder's fan, introduced by Dr. Holland, greatly lessened this risk; but strange to say, the improvement met with a vigorous opposition from the very men it was intended to benefit. The certainty of speedy death had operated to their advantage in one way; it had kept up for them a high rate of wages, by limiting their numbers, and frightening new comers. A needle-pointer could earn as much as a pound a day during that brief period when his powers were at their best. If the occupation were rendered harmless, the rush of competitors from other less lucrative branches would soon reduce his wages to the common level, and his dull selfishness regarded this as an invasion of his monopoly. He resented as an injury to himself the merciful expedient which would deprive him of the opportunity of selling his life for gain. The fan-blower exhausted the air from a tube with a funnel-shaped mouth, placed at the back of the grindstone, and the particles were drawn down into a box underneath. Despite opposition, the invention became universally applied, and pointing was as harmless as any other branch of the manufacture. Another revolution was impending which was much more fatal to the interests of the pointers. This was the introduction of the needle-pointing machine, generally supposed to be a German invention, but of which the first crude idea had appeared in a machine of English construction some years before. This latter was only partially successful, but there was enough in it to alarm the hand-pointers, who, on its becoming disused, clubbed to purchase it, and broke it up solemnly on Redditch Green. The present machine is very beautiful in its construction and effective in its working. The grindstone, which is broader than that used for hand-pointing, is turned with the most perfect accuracy, and its periphery is hollowed out like that of a pulley, only much shallower, and the true arc of a circle. An iron wheel, covered with vulcanised india-rubber, revolves over this at an oblique angle, very slowly, being so hung as to traverse the hollow of the stone without touching it. A steel band encircles this wheel underneath, between it and the stone, which still is not actually touched, though the band lies very close to it. Down an inclined plane at the side a man feeds the wires on to the wheel, which takes them down between itself and the steel band, causing them to rotate at the same time, and bringing their points gradually to bear on the stone. At first the extreme points only are touched, but as the slowly-rotating wheel pursues its diagonal course, the bevel extends up the shaft of the needle, and gives it the swelling taper which so much delights the seamstress. As they come up to the opposite end of the steel band, the wires drop off into a trough, and are ready to be put through again for the purpose of pointing their other ends; each wire, be it remembered, having to form two needles. Forty thousand needles can be pointed in an hour by each of these machines. A fan-blower acts upon each machine, and the shower of sparks, which represent fine particles of steel, are drawn down the tin tube by a strong draught. A machine of similar construction brightens the middle part of the wires, which are black and scaly from having been heated red-hot in the straightening, the object being to make a clean place for the stamp to act upon, and form the two heads. This is the next process. A pair of delicately-cut bright dies gives the shape of the heads, the indentation for the eyes, and the gutter or groove, if any, which leads up to the eyes. There are perhaps as many as thirty different shapes of eyes known to the trade, each being recommended for one quality or another, though the office of all is merely to hold a bit of thread. There are round eyes, square eyes, and oval eyes; eyes egg-shaped, pear-shaped, and pippin-shaped; and many others. The stamp flattens out the soft steel on either side, and the heads of the two needles appear as if embossed in high relief from a small flat plate. A man stamps them one by one, having acquired from long practice great dexterity in placing them quickly on the bed; and 50,000 or so is but an ordinary day's work. The next operation is to complete the puncture, which is done by a girl at a press. The tools are made to work with great nicety, and both holes are cleanly pierced with one blow. The next job is to thread or spit the double needles on wires passed through the eyes. This was formerly done by very young children, and when the Factory Act came into operation and prohibited their employment, there was an outcry that the prosperity of Redditch was ruined for ever. But the needle district still stands where it did, and its shadow has not been lessened by the emancipation of the little ones. A number of needles being spitted and pushed up close together, are handed to a man whose business it is to file off the flattened projections left by the stamp. He places them flat down on a strip of wood before him, and a couple of steel clips, tightened down by a treadle under the bench, hold the points firmly while he dresses first one side and then the other of the whole row. The double needles then easily break asunder in the middle, each side being still spitted on its own wire. He then seizes the shafts with a pair of wide-jawed pincers, and holds them over a peg while he files up the row of heads, rounding them into shape. The next step is to smooth the insides of the eyes, which, having been cut out with press tools, have necessarily sharp edges which would infallibly cut the thread. For this purpose they are again threaded upon fine wires which fit them loosely, and which have been previously roughened and hardened. When a number of such wires have been threaded, they are fixed in a frame, the needles dangling loosely down, and the machinery being set in motion, the frames are shaken backwards and forwards as a gardener would shake a riddle. This of course sets all the needles dancing and wagging with great activity, and in time all the corners are worn off, and the eyes become burnished smooth and clear. This process is very amusing to witness. The needles are now ready for the hardener, whose business it is to get them to the temper which will render them trusty in the hands of the housewife. He places them on iron plates of suitable shape, and heating them to the proper degree of redness in a furnace, turns them over into a liquid composition in which oil is the principal ingredient. Great care is requisite in watching the heating of the needles, and an unskilful workman would soon spoil a great quantity. Being afterwards washed and dried, they are brought down to the requisite temper by re-heating, in the same way as are steel pens. They have then to be picked over for "crooks." Women's fingers are best for this work, being more delicate in the sense of touch. A perfectly level slab of stone, of some smooth texture, is laid upon the bench, and the operator, feeding down the needles rapidly with her left hand, rolls them over one by one under the fore-finger of the right upon the stone. If the needle rolls smoothly and evenly, it is straight; if not, it is quickly cast aside as crooked. The bent ones are afterwards straightened one by one by taps of a very small hammer upon a tiny anvil. It was at one time the usual practice to harden the needles in water, and the sudden transition from heat to cold caused many of them to go crooked, thus furnishing occupation for the straighteners. When the oil bath was substituted, crooked needles became the exception, and the introducer of the method was instantly pounced upon as an enemy, and driven from the town by repeated mobbings. After this stage the needles are "weighed up for the mill," a purely warehouse operation, which has nothing to do with their manufacture, but which is nevertheless highly necessary for the manufacturer, who tests by this means the amount of waste which has occurred since the first process, and is enabled to judge of the quality of the steel he is using. The scouring mill, which comes next, marks a very important stage in the making of the needle. The method of scouring in the very early times of needle-making was primitive enough. The needles were wrapped up in buckram, with emery dust and olive oil, and rolled to and fro under the feet of the workmen as they sat at work at some other process. Now, extensive mills, worked by water or steam power, are used for the purpose. Long rolls of coarse cloth or canvas, each containing about 50,000 needles, with a small quantity of powdered quartz and soft soap, are bound up tightly along their whole length, and well fastened at the ends. Two of these rolls are placed in each machine, of which there may be twenty or thirty in the mill. The machine is a sort of mangle, having a massive fixed bed faced with iron, and a heavy slab of wood resting upon it, under which the rolls are placed. Heavy wooden arms, moved by cranks in the main shaft, work these slabs to and fro, they being weighted according to circumstances. For no less than eight days are the needles thus mangled, but their canvas wrappers are changed several times during that period, and they receive fresh dressings of scouring material. If the object were merely to brighten the needles, one would think that some easier and quicker agency could be found than the ponderous creaking machinery of the scouring mill, but this rolling of the needles together under heavy pressure assists in giving them a contour—a perfect swelling rotundity of form—which is said to be unattainable by any other means. After being again washed and dried, they are taken into the "bright" shops, which is a sort of promotion in their career. Here, for some few stages further, they are turned over to the delicate fingers of women, whose first care is to reduce them to order. When they come from the scouring mill, of course the needles are all lying in a confused heap, and before anything more can be done with them, they must be "evened," or placed in decorous rows side by side. For this purpose, the girl puts a small shovel-full into a shallow pan, which she shakes gently with one hand, all the while stroking the needles with a sort of metal paper-knife into a longitudinal direction. In a short time they all fall into regular order, and are then carefully lifted out and placed upon narrow strips of box-wood, with ledges at the ends to keep them from rolling off. The next business is technically called "handing," and consists in extracting from the heap those which are slightly longer than the rest. With all the care exercised in cutting the wires in the first instance, and in the after pointing and dressing, the needles will differ in length by some minute fraction of an inch, and the object of this process is to sort them. The needles, as they lie upon the strips, are gently patted at the ends with the iron paper knives to level them, and then the girl touches them lightly on both sides with the ball part of the palms, the longest needles sticking to her hands, and allowing her to work them up gently through the heap to the top, when they are carefully lifted off and placed aside. She then tries again for the next longest, and so on, there being perhaps as many as ten "handings" from a heap. An unpractised eye could not detect any difference between the longest and the shortest, but this nicety is necessary for the final arrangement of the needles in those small paper packets in which they reach the consumer. When they are well handed and sorted, they are still in some little disorder, the points being some one way, some another, and this has next to be rectified. A girl wraps a piece of wash-leather or cloth round her right fore-finger, and backing up one end of the needles with her metal paper-knife, touches the other ends lightly with her clothed finger, and pulls out all those whose points stick in the material; the heads, of course, not sticking in, are left behind. The well-arranged needles have now to be picked to see if any defective ones have accidentally crept in. They are rejected for damaged heads or points, for "flecks" (little blacks or specks in the metal), and for crooks. The girl lets them fall towards her down an inclined plane one by one with great rapidity, and as the slightest defect catches her eye, the offending needle is instantaneously jerked out. It would be difficult to tell, from an examination of any rejected needle by itself, why it was cast out; it requires to be seen in connection with the perfect ones for its fault to become apparent. The next thing is to "blue" the heads for the purpose of softening the needle a little more at that part to prevent them breaking off across the eye. The usual method in the trade has been to lay them evenly upon a stone, with the heads slightly hanging over, a red-hot iron being brought up against them, and held till they turned colour. A much more elegant method has now come into use, and the heads are beautifully blued by a self-acting machine. The needles are fed from an inclined plane to the circumference of a wheel, which has transverse grooves upon it, each capable of taking up one needle. A band keeps these needles in their places while the slowly-revolving wheel takes their overhanging heads through the flame of some gas-jets, the time occupied in traversing being just sufficient to give them the colour. It then deposits them on an endless moving band, which carries them back again, and drops them evenly into a trough. After this they get into the hands of men for the final touches, viz., grinding, by which the outward shape of the head is nicely rounded and finished; setting, *i.e.*, sharpening the points, in the sense that a razor is said to be set; and polishing, by which an exquisite glaze is put upon the needle from end to end. All these processes are performed upon little stones and "bobs," no larger in diameter than a cotton-reel. As a last attention, they are well rubbed between two pieces of buff leather, lest any moisture should remain upon them from the hands of the workpeople, and are then ready for the packing room.

A great sensation was made in the trade some years ago by the introduction of "drilled-eyed needles," which took the market wonderfully, on account of their superior appearance. They were not really drilled, but only countersunk a little on both sides, the hole having been previously pierced through with a press. It was soon discovered that they cut the thread, the countersinking having left a ridge in the middle. A great many of these so-called "drilled eyes" are made now, but as a matter of course, the process is only applicable to round eyes: those of longitudinal and fancy shapes have to be treated in a different manner. A small buff "bob," stuck full of short spikes or points of wire, revolves very rapidly. The eyes of the needles are pressed against this, and it rounds down the sides and edges of the orifice very effectually. This process is called "curing."

It is pleasant to see the large and lofty workshops, with windows looking over miles of prospect, of some of the larger factories. The one we had the pleasure to visit—that of Messrs. S. Thomas and Sons—is of modern build, and not only contains the newest and most improved machinery, but seems to have been specially constructed with a view to the health and comfort of the workpeople. All is beautifully clean, and every precaution is taken to keep the atmosphere pure and wholesome. A large workroom, which in Birmingham would be made to hold at least fifty workwomen, is there tenanted by not more than a dozen. They get up the very best work, as our account of the precautions taken in the finishing processes sufficiently shows. It must not be supposed that *all* needles are prepared for the market with such extraordinary care; a great many of vastly inferior quality are doubtless manufactured, and with far inferior appliances, but the readers of this work will be most interested in the newest and best developments of the trade. It is to the enterprise of this firm that the town will be indebted for its new wire-mill. They make their own machinery, and, up to a recent period, even their own gas; and their extensive manufactory is in every respect a model.

Not less than 100,000,000 needles are made weekly in the Redditch district. Every housewife can now obtain, at a very moderate price, an assorted stock of these useful implements, to suit any purpose for which she has occasion to use them.

The English ladies derived their needles from Spain and Germany until Queen Mary's time, when, as Stowe relates, "a negro made fine Spanish needles in Cheapside, but would never teach his art to any." With him died out the secret; but it was introduced in the next reign by a German, and other needle-makers also came from Normandy. It was first established as an English manufacture at Long Crendon, in 1650. From thence it travelled gradually through one or two smiling villages in Warwickshire, as though feeling for its final resting-place, which it ultimately found in Redditch. There it is likely to remain. The only competitors in foreign markets are the Germans, but the quality of their goods will not bear comparison with the productions of Redditch. For cheap and common articles the German price cannot be touched.

MINING AND QUARRYING.—XVIII.

BY GEORGE GLADSTONE, F.C.S.

TIN (*continued*).

TIN PLATES—TERNE PLATES—PROCESSES OF TINNING OTHER METALS—SILVERING GLASS—OTHER APPLICATIONS—INCREASING VALUE OF TIN.

One of the most important applications of tin is due to the faculty it possesses of adhering to the surface of iron, and of forming an actual alloy with that metal, which is brought into action in making tin plates. By this union of the two metals a thin sheet can be produced which shall have the strength of iron, but which shall not be liable to rust as that metal is; while on the other hand it has a strength far exceeding that of tin. Nevertheless, the manufacture of tin plates in this country only dates back about 150 years, though it was adopted in Germany a century before.

The foundation is iron, which has to be rolled out into very thin sheets. A thoroughly tough and uniform metal is required for the purpose, and much care is therefore exercised in making the sheet iron. Charcoal plates, which are the best (the others being called coke plates), are so named because charcoal is used in the finery. The refined bar is subject to the hammerings, rollings, etc., which all finished iron has to go through; and is then ready to be rolled out to the size and thickness required in this manufacture. Here it is rolled, doubled up, and re-heated over and over again, the greatest possible care being taken that no scale shall form on the surface of the iron, because if this should be rolled into the metal it will produce a roughness of the surface in the subsequent pickling, which will injure the quality of the finished plate. With this object the temperature of the re-heating furnace is kept low. The edges are then trimmed, so that the plates shall be of the exact size ultimately required; there being five different sizes common in the trade, as well as variations in the thickness of the metal.

The plates are then set edgewise in a bath containing the pickle, which consists of a weak solution of sulphuric or hydrochloric acid, usually in the proportion by measure of 16 of water to 1 of the acid; the pickle is gently warmed over a fire until all the oxide is removed from the surface. The acid used for this purpose should be quite free from arsenic, for fear of which sulphuric acid made from pyrites should be avoided. After this the iron sheets are carefully washed, and then put into the annealing pots, which are closed down and then exposed to a bright red heat in a reverberatory furnace. The next process is to roll them cold, between highly-polished rollers, after which they pass through a second annealing and bath of pickle, by which time a perfectly smooth and bright surface is attained.

Thus prepared, the plates pass into the hands of the tinman, whose business it is to give them the coating with the more valuable metal. For this part of the operation a series of cast-iron vessels are required, which may be conveniently arranged in a row as shown in the accompanying diagram (Fig. 11) and the ground plan (Fig. 12). The plates, after being scoured and rubbed clean, are put into the pot marked A, which is filled with grease, kept in a liquid condition by the heat from the fire below, and the flue which passes round the sides, as shown in the drawing. When thoroughly coated with the grease they are passed into the tin-pot B, which contains a bath of melted tin, the surface of which is also preserved from contact with the air by a superficial stratum of melted grease. Some pieces of wood are immersed in the tin to separate any impurities there may be, upon the same principle as that already described in our last paper, when treating of the refining of the metal. From this they are removed to the wash-pot C, which is made in two compartments, both containing melted tin and grease, but kept at a lower temperature than that in B. The quantity of tin used in both these is superior, the best of all being in the smaller (left hand) compartment of C. When the plates are taken out of the larger compartment, they are laid upon the table G, and carefully rubbed on both sides with hemp, after which they are dipped into the smaller bath to receive a final coating for the purpose of obliterating any marks made in the rubbing. The next pot, D, is filled with palm-oil and tallow, which is kept just hot enough to melt off all superfluous tin, the plates being stood in it on edge that the tin may be free to run down to the bottom of the pot. The next, E, is the receptacle in which they are left to cool; and the last, F, is the list-pot, in which only the lower edge of the plate is inserted, so as to melt off the beading of tin which will have accumulated there while standing in the grease-pot, D. The plates have then only to be cleaned with bran and rubbed with flannel, and they are ready for packing in boxes for sale.

There are a variety of marks indicative of the size and weight of the plates which make up a box, and which are common to both descriptions—charcoal and coke plates. They are known as commons, C; and crosses, X; with common doubles, C D; and cross doubles, X D; and common and cross small doubles, C S D and X S D respectively; the further subdivisions being indicated by numbers from one to four. A box of the first two categories contains 225 plates; of the common and cross doubles, 100; while of the small doubles 200 constitute a box.

Tin can also be applied with advantage to other surfaces than iron. In a former article galvanised iron and its properties have been described, and this may serve also as a basis for a tin coating. In such case the surface of the zinc must be freed from all oxide, by immersion in a weak acid pickle, and the sheets then dipped as above described in a tin bath, the surface of the molten metal being protected from oxidation as before by the surface being covered with melted tallow or oil.

Lead may in like manner be coated with tin: in both cases it is desirable to warm the inferior metal to a point nearly approaching that of the melted tin. It is capable of being rolled out into thin sheets after the coating has been added, and if any flaws should be found on the surface after such operation, the plate is usually dipped again.

Small iron articles are often tinned in another manner. The goods must be cleaned of all rust by the action of an acid as usual, then quickly washed, and placed at once in a jar or close vessel along with some tin and chloride of ammonium. The jar is then placed in a furnace and heated, being kept in motion all the time, so as to bring the tin into contact with all parts of the articles which are to be coated. When taken out of the vessel they are washed with water to remove the sal-ammoniac, and rubbed up with hot bran or sawdust to give them a brighter surface.

Any of the fusible alloys of tin described in the preceding article will serve as a coating instead of the pure metal.

Terne plates, for instance, are coated with an alloy of tin and lead in any proportion, varying from one-third to two-thirds of tin. They do not possess the brilliant surface of the real tin plate, but are useful for various purposes, such as roofing, for which the other article is too expensive. Terne plates are sent to Canada in considerable quantity, where they are applied to the purpose just named.

Copper vessels are often tinned inside, especially those intended to be used in cooking. On account of their shape, and because only one surface is to be coated, a different plan is adopted in this case. The surface to be tinned is first sprinkled with chloride of ammonium and then heated, which causes the salt to dissolve and enter into combination with any oxide on the surface of the copper. The whole of it is rubbed during the heating until every part is quite bright and clean. The copper being still maintained at a temperature sufficient to melt tin, some of this latter metal is placed in contact with it, and as soon as it is sufficiently melted it is rubbed by means of a pad all over the surface of the copper. The two metals combine, forming a true alloy. If the workman should be lavish of his material, and make the coating too thick, the outer surface will be pure tin, which can be melted off again without affecting that portion which has entered into actual combination with the copper, the melting-point of which will be very much higher.

A mixture of lead and tin, containing from one-fourth to one-half of the former, is sometimes used as a substitute for the pure metal, and is applied in the same manner as the foregoing. The alloy melts at a lower temperature than tin, and a less quantity will suffice to cover the surface of the copper, so that it has both practical and economical advantages; and it does not appear that, if used carefully, the lead will be dissolved out and enter into the food cooked in the vessel so as to be injurious to health. It may readily be distinguished by the dull surface it presents, similar to that of terne plates.

Another combination possesses some important advantages, though it is not quite so easy in its application. It is a compound of iron and tin, of which the former metal must not exceed about 12 per cent. A considerably higher temperature is required to melt this alloy, and it is therefore necessary to heat the vessel to a low red heat; while kept at this temperature the operator presses the end of an ingot of the alloy against the heated surface, and thus rubs it all over until it is sufficiently coated. When cool, any roughnesses are rubbed down so as to give it a good and smooth surface. This compound is very durable, and the articles so finished will stand a much greater heat than those coated with either the pure tin or the alloy with lead.

There is another application of tin, very different in its character from any of the preceding, which must now be referred to—the so-called silvering of glass for mirrors. The material commonly used for this purpose is actually an amalgam of tin and mercury. The plan adopted is to spread upon a flat table a sheet of tin-foil of rather larger dimensions than the piece of glass to be silvered, and then to brush some mercury over it as evenly as possible. When this has amalgamated with the tin some more mercury is poured upon it, and then the glass plate is slided edgewise over it, the edge of the glass dipping slightly under the surface. The object of bringing the two into contact in this way is to cause that part of the amalgam which has been exposed to the air, and which has therefore suffered some slight oxidation, to be pushed aside, so that none but the perfectly bright metal shall come into contact with the glass. The plate is then loaded with heavy weights, and inclined at a slight angle, by which means all the uncombined mercury is expressed and drains out. It is then stood on its edge until the amalgam has become dry and firm.

Tin-foil is made by the rolling and hammering out of tin, which can be carried to about $\frac{1}{1000}$th of an inch in thickness; and tinsel is produced by the coating of thin leaves of brass and other metallic compounds with a film of tin. Thin plates of tin are also often used for ornamental purposes, as they can easily be stamped with any device that may be desired; but as the pure metal is very soft, this application can only be employed where there is little risk of external force.

Tin is also employed by the manufacturer of coloured glass, of majolica, and other ornamental ware of that description, which need not be particularised here, as these uses have already been described in other series of articles. The student may be referred to Article XII. on "Colour," where the effect of opalescence in glass is described as being produced by the oxide of tin, and the opaque whites in majolica, and other enamelled stone wares, are stated to be due to the use of the same metal. In Article III. on the "Practical Application of the Fine Arts," the effects of the salts of tin in deadening the colours of glass are further detailed.

It will be readily inferred, from the description of the manifold uses of tin given in this and the preceding article, coupled with the fact of its very limited geographical distribution, that it is a source of no small wealth to the two counties which produce it. The statistics of the trade tend to show that the yield of tin scarcely keeps pace with the demand, and that as a consequence the value of the metal shows a tendency to rise. This has recently been the case to a very marked extent, as the supply of tin from Banca has, from some unexplained reason, fallen off; but that it is not a mere temporary fluctuation may be evidenced by going back a year or two, when prices were not equal to what they are now. For instance, in 1869, the black tin raised in Cornwall and Devonshire amounted to 14,725 tons, valued at £1,028,000, yielding 9,760 tons of metallic tin, valued at £1,201,450; exceeding the previous year by 460 tons of tin, and £200,000 in value. If we go back to the last century, the largest annual produce appears to have been 3,725 tons; and for the first thirty-eight years of the present century the greatest return was 5,290 tons. Since then it has been increasing (subject to minor fluctuations) to the above total. The annual value has been, during the same period, liable to very severe fluctuations. During the troublous times immediately preceding the final overthrow of the first Napoleon, the value per ton, as may reasonably be inferred, reached an unprecedented figure, the foreign tin at that time being practically excluded; but on the restoration of peace the price fell from £157 per ton, its maximum, to about two-thirds, and within a few years to about half that figure. There seems every prospect now that the demand will keep full pace with the supply.

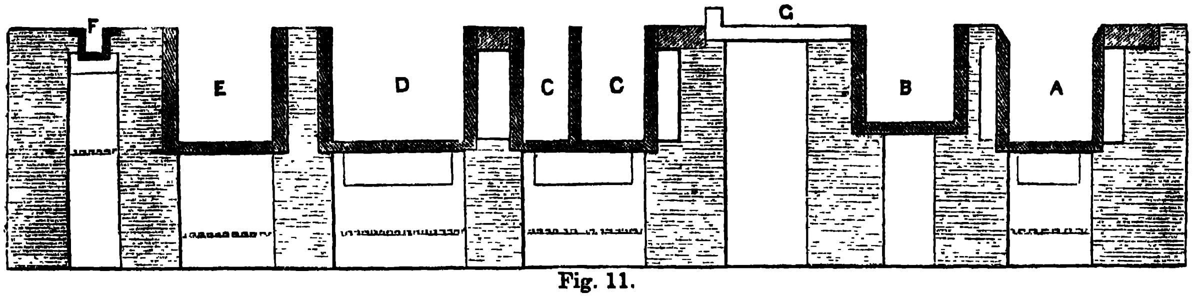


Fig. 11.

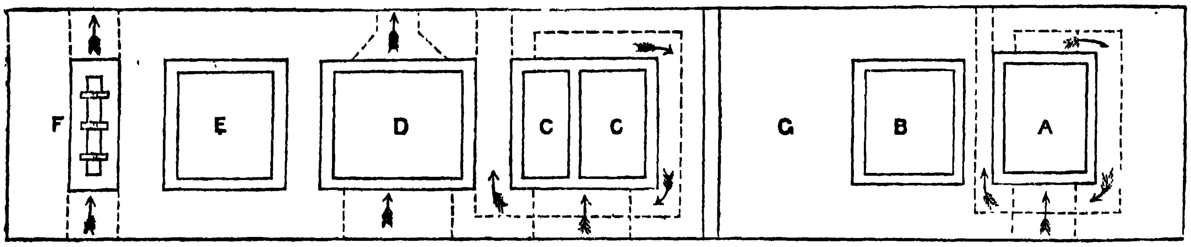


Fig. 12.

SILK CULTURE.—IV.

By Alexander Wallace, M.D.

PREPARATION FOR SPINNING—METHOD OF MAKING SILKWORM GUT—CHRYSALIS—EMERGENCE OF MOTH—RECEPTION AND PRESERVATION OF EGGS—QUALITIES OF COCOONS.

And now the critical period advances when the value of the crop, and the result of past labour will be determined. Up to this point all has been uncertainty. Thunderstorms, sudden changes of temperature, hot winds, insufficient ventilation, unhealthy food, or improper manipulation might so far have compromised in a very brief period the safety of the crop; but the cocoons once spun, the rest is a certainty, and the harvest secure. As, moreover, cocoons vary much in quality owing to the health of the worms, till they are gathered, the quantity and quality of the crop is a matter of speculation. The last few days, therefore, are anxious yet joyful ones, for the labour and toil, hitherto excessive, will after this diminish. In Japan a bed is prepared for the worm to spin in, consisting of rape or rice straw cut into short lengths and loosely spread on the tray; but in Europe the *manelli*, or bundles of heather or broom, asparagus-stalks, or seed-stalks of any of the cabbage tribe, etc. etc., are set up round three sides of the tray, while food is scattered very thinly about the tray. The "bushes" or "fagots"—as these bundles of heather, etc., are commonly called—should be longer than the space between the trays, and placed somewhat aslant, so that the worms may better crawl up, and that the liquid voided by them may not fall direct on those below. Each fagot may be fifteen inches apart from the next, so that a smaller fagot may be afterwards inserted between each. Dandolo advises that each fagot should touch the tray above, so that its branches curl over. I am doubtful about the propriety of this course—(1) because the worms will ascend from the lower tray to those above, which would not be well, unless they were all of the same age to a day; (2) because ventilation is almost entirely impeded by doing so. The worms soon hasten to the *manelli* and crawl up, "mounting," then, seeking a convenient spot in the interstices of the stalks, commence their cocoons. It is a matter of importance to allow sufficient space for the worms, for if crowded, two or more will spin their cocoons together, which, being made of two threads, cannot be reeled (doubles), and are therefore of inferior value. One per cent. of doubles is the ordinary average in a good sample; five per cent. is the highest per-centage allowed in the sale of cocoons. Should the doubles exceed that percentage, less value is given for the lot. Some races, especially the bivoltine, average more doubles than other races. Worms may now be lifted up, when wandering away from the bushes, by the finger and thumb, without undue squeezing, and placed thereon. In thus removing worms, care should always be taken to take hold of the fore part of the body, and draw the worm upward and backwards; he is thus induced to loose his foothold—if drawn forward he will resist, and probably receive damage. The noise now in the silkworm-room is very perceptible, resembling a quiet rustling, partly caused by the worms spinning, partly by those moving about, partly by the action of the jaws of those still feeding. Temperature should now be kept even and steadily warm (about 70° to 75°), and ventilation well maintained. At this stage, if the worms are weak, some will die while spinning, and being concealed among the bushes, a very powerful odour, noxious to the living worms, will emanate. Any unhealthy or weakly worms should therefore be looked for and thrown away. After fastening the outside strands, by means of which the size of the cocoon is determined, the worm weaves first the outer loose envelope; but gradually contracting its movements, spins the tighter and closer body of the cocoon, and in twenty-four hours is hidden from sight. At about the third day the cocoon begins to

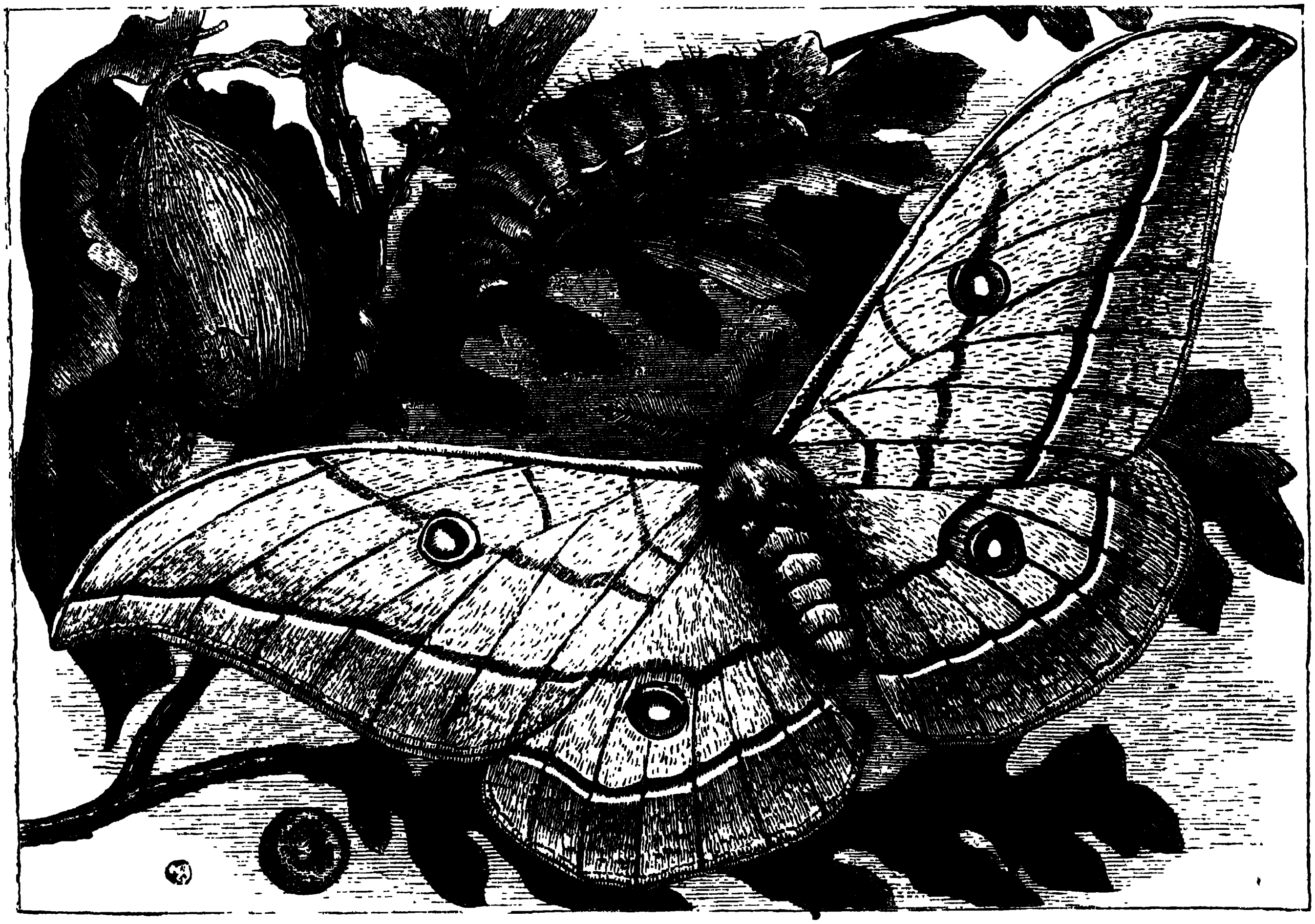


Fig. 5.—CATERPILLAR, COCOON, AND MOTH OF THE BOMBYX YAMA-MAI.

assume a hardness, and in a week is ready to be gathered. As the worm spins its cocoon from end to end in one thread, it is important not to disturb it during cocooning, lest the thread be broken. Good cocoons are those which have such a substance of silk that they resist pressure and feel hard to the touch, and at the same time preserve the shape and colour peculiar to their race. It is a very pretty sight to see the bushes well filled with white or golden cocoons.

Should any worms appear ripe for spinning, but unable or unwilling to rise, or should any fall to the ground while mounting, they should be removed to a separate frame, and a handful of seed-stalks or a few bushes of heather be laid down instead of set upright, upon or under which, in all probability, they will crawl and make a good cocoon.

But some worms, though fat, heavy, and generally very yellow, will not be induced to spin either on the high or low bushes. These should be collected every night and morning, and put into a basin of vinegar and water, for the purpose of making gut for fishing. After remaining in the basin for twelve hours they are thus treated :—

A board should be prepared 6 inches by 30 inches, with a row of pegs at each end, and notched all round the edges. Two intestinal tubes run through the silkworm, one on each side, of a clear transparent appearance; these are the silk receptacles, and should be separated from the head of the insect while in the vinegar and water, and the threads, one by one, drawn out rapidly to their full extent, and fixed at full stretch on the board by means of the pegs at one end and the notches which receive and fix the other end. This must be done quickly, as the air soon hardens and stiffens the string; they must on no account be passed through the finger and thumb, as they are of no value if flat; roundness, strength, and length are the points of value. The yellow mucilage which coats the strings is removed afterwards by being boiled in soap and water.

After the gut is drawn out the board should be placed in the sun to dry, and the old strings may be removed night and morning when new ones are put on the board.

To clean the gut, take a piece of soap the size of a nutmeg, and boil it in a gallon of water. When it is completely dissolved, put the gut into it and boil for ten minutes; take out and pass the gut through cotton-wool to remove what may be left of the yellow matter, but so lightly that the gut, which becomes soft by boiling, may not be flattened by pressure; when again stretched and dried on the board it becomes clear and strong.

Experience is necessary to do this well; but it is worth the trial with silkworms which would not spin, and would otherwise be lost—the more so as good silkworm-gut is really valuable, and I have been offered as much as four guineas per 1,000 pieces of the best gut. Silkworm-gut comes chiefly from Spain; its manufacture is well worth the attention of sericulturists at home and in the colonies.

After the cocoon is spun the caterpillar rests within the structure; having voided the contents of its intestinal canal and its silk, it contracts still further, throws off the skin, and becomes a chrysalis. The insect lies in this state about three weeks, and then emerges a moth. To get out of the cocoon, the moth splitting first the pupa-skin about the head and face, pushes these parts against the apex of the cocoon; the nose, being furnished with an alkaline secretion, is continuously applied. The alkaline fluid dissolves the gum and loosens the threads, and the moth pushing outwards separates these and emerges, leaving a small round hole in the cocoon, thus rendering it useless for reeling purposes. The moth, at first a feeble, soft thing, clings to the cocoon, if possible, in such a position that the wings may hang down over its back. These speedily enlarge, and after an hour or two are fully developed, and the moth is ready for the next stage, viz., wedded life. But prior to the moth emerging the hand of man interferes; for in order to preserve the silk for use it is necessary to reel the thread, and as this cannot be done after the cocoon is empty of the moth, it becomes necessary to secure the silk either by reeling the cocoon in the short interval which elapses between cocooning and the exit of the moth, which can only be done where there are few cocoons to reel; or by destroying the pupa inside by means of heat. This is effected in the East by exposing the cocoon for several days to the sun's rays, which are there sufficiently intense to dry up the life of the pupa. In Europe more commonly dry heat of an oven or of a steam-chest is employed. I found two hours' exposure in a baker's oven after the bread was drawn, at a temperature of about 170°, was sufficient to dry up the pupa thoroughly. This may easily be tested by cutting open a cocoon taken from the middle of the mass in the oven. When the pupa is reduced to a hard dry mass, easily reducible to powder, it is sufficient; but if still a moist mass, heat must be maintained for a longer time. Care must be taken that the cocoons be not burnt. Cocoons thus treated, and thoroughly dry, will keep for years without serious deterioration; may be pressed and packed into bales, and will travel round the world, and when placed in hot water will again spring into shape and reel well. When stripped from the bushes the cocoons should be denuded of the outer envelope of floss, which should be collected separately, having a value of its own for the manufacture of spun-silk. The cocoons thus denuded are sorted into those that are required for breeding purposes, which should always be chosen from the best shaped and stoutest cocoons, in order that, in accordance with the principle of selection, the progeny, following the example of their fathers, may produce superior cocoons. One-sixtieth part of the produce used to be retained for stock; but owing to the changes caused by the prevalence of the disease in Europe, very few cultivators rely now on their own "strain." The remainder are again sorted out into several classes for reeling purposes, and may be taken to market or sent to a filature (silk-reeling establishment). Eggs and dry cocoons may be transferred from one end of the globe to the other, but in no other stage will the *Bombyx mori* travel safely. Colonists are especially recommended thus to take advantage of the high prices of European markets, and send over their crops in one of these two ways. In order to obtain the best eggs, only those moths which are vigorous, well-formed, and free from blemish are allowed to copulate. The male may be distinguished by his elongated narrow abdomen, and by his tail, when expanded, being forked—or bifid; the female by her larger size, plump abdomen, and ovipositor, which is light-coloured and of a somewhat elongated pyriform shape. The moths emerge early in the morning, and are often found paired on the cocoons. Those coupled should be removed to a separate tray (the wings of the female being taken hold of), and allowed to remain undisturbed till the evening, when they should be separated, and the females placed on the paper or cloth intended for the eggs. In Japan the cards on which the eggs are laid are often placed in a frame of polished wood; the moths, disliking the polished surface, confine themselves to the card, and there deposit the eggs. It is a good plan to hang the cloth somewhat perpendicularly, and to tilt the upper portion of the cloth forward, so that any excretion from the moths may not fall upon the eggs already deposited. After separation from the male, and before the process of oviposition takes place, the act of defecation, or evacuation of a brownish coloured fluid takes place, or, as it is termed, the female clears herself. This act generally happens in the wild Bombycidæ, after the wings are dried. When the moth first begins to flutter about, and prior to copulation, the males are very ardent after the females, and if no females are at liberty, two or more males may be seen joined together. This act has also been observed in the Chinese species *Bombyx Pernyi*. As the moths emerge the empty cocoons should be removed. These are now only useful for the manufacture of spun-silk, and also as samples of the race, to be shown when the eggs are offered for sale, and to which samples the eggs should come true, *i.e.*, produce cocoons of like value. The egg when deposited is a flattened disc of a pale yellow tint, soon assuming a light brown tint, gradually changing into a dirty lilac grey. If the egg remains yellow or white, fecundation has not been effected. The eggs first laid are the largest, and produce the best worms; then the bulk of medium quality, the last eggs being smaller and of less vigour. Hence a careful educator will watch his moths during oviposition, and after the first twenty or thirty eggs have been laid (which he will retain for his own use) will remove the moth to another card or cloth, and after she has laid there about 100 eggs will throw her away, or retain the remainder of her produce on a separate cloth as inferior. Dandolo says that 22 square inches of cloth are sufficient to contain on the surface of the cloth 6 or 7 oz. of eggs. In placing the moths upon the cloths, begin at the top and go downwards. Eggs may be kept in an airy room. Each female will lay between 300 and 400 eggs.

As to the qualities of the cocoon.

There are nine different qualities. 1. *Bons cocons* (good cocoons), which have been brought to perfection. These are by no means always the hardest, but are compact, free from spots, and of a good shape.

2. *Cocons pointus* (pointed cocoons) have one extremity rising in a point. These, after affording a little silk in reeling, break or tear at the point, where the thread is weak, and they cannot be wound farther, as the fracture would occur as often as the thread reached the weak point.

3. *Cocons faibles* (weak cocoons) are rather larger than the regular cocoons, but do not contain more silk, their texture being less compact. These are separated from the other kinds, because in reeling they must be immersed in colder water, in order to avoid any furzing or entangling in the operation.

4. *Cocons doubles* (double cocoons). The threads of these are so mixed that frequent breakings occur in reeling, and often they cannot be reeled. In any parcel the proportion will reach from one to five per cent., which is the highest allowed without reduction in price.

5. *Cocons satinés, goufflons* (flossy cocoons). These are very imperfect cocoons, with a loose contexture, sometimes to such a degree that they are transparent. These cannot be reeled.

6. *Cocons ouverts* (perforated cocoons), as their name denotes, have a hole at the end, generally from the moth having escaped. They cannot be reeled in the ordinary method, as the thread always breaks when it arrives at the perforated place. Latterly, however, it being seen that the moth does not rupture the threads, but only separates and pushes them apart during the act of emerging, having previously liquefied the gum which bound the threads together by means of the alkaline fluid emitted from the face, attempts have been made to adapt machinery to their reeling, and silk has thus been produced.

7. *Chiques, cocons chiques*, are cocoons wherein the insects have died before perfecting their task. These are known by the adhesion of the worm to the cocoon, which prevents it rattling when shaken. The silk of these is as fine as of the first-mentioned quality, but not so strong nor so brilliant; and they must be wound separately, as they sometimes furze in reeling.

8. *Cocons tachés* are defective cocoons, spotted or rotten. They furnish foul bad silk, of a blackish colour.

9. *Dragées* (calcined cocoons) are those wherein the worms, after having completed their cells, are attacked by a peculiar disease which sometimes petrifies them, and at other times reduces them to a white powder—a fungoid disease known by the name of *muscardine*. In the former case they are called comfit cocoons, from the resemblance borne by the withered worm to a sugar-plum. The quality of the silk, so far from being injured by this means, is generally excellent, and it is even in greater quantity than in the cocoons of healthy worms. Comfit cocoons may be distinguished also by the peculiar light rattling sound of the dried worm within. They are much esteemed, and fetch a high price, but are not of frequent occurrence. 3 lb. of fresh or green cocoons will make 1 lb. of dried cocoons, and about 4 lb. of dried cocoons will produce 1 lb. of reeled silk; it therefore takes about 12 lb. of fresh cocoons to produce 1 lb. of silk.

BRICK AND TILE MAKING.—VI.

By Gilbert R. Redgrave.

BRICKS, TILES, AND TERRA-COTTA.

The manufacture of flooring-tiles has, we think, made greater progress during the present century than any other branch of the ceramic art; and this industry as now practised in Staffordshire, presents many features of great interest, and differs in many respects from the manufacture of the coarser wares we have noticed in our previous numbers. The old-fashioned 9-inch or 12-inch tiles made in wooden moulds in the same way as bricks are made, have now been almost entirely superseded by the thin machine-made tile, which has scarcely one point in common with its clumsy prototype. Tile-making, or at any rate the manufacture of encaustic tiles, is now a business entirely alienated from the brickmaker, requiring as it does a most costly plant and a totally different mode of procedure to the heavier clay goods. In some country places, however, oven tiles, floor tiles, and quarries, are still made and burnt along with the bricks. We need not devote much time to the consideration of the tiles made from brick earth, as the processes in every respect resemble those we have previously described. A carefully-prepared clay is made use of, and the tiles when partially dry, are smoothed over or trimmed with a steel instrument or knife, which gives them a silky, lustrous surface, and is supposed to make them more dense and durable. A tough clay is generally selected, such a clay, in fact, as would be employed for roofing-tiles; the tiles are generally either 6 inches, 9 inches, or 12 inches square, though 4-inch tiles are sometimes made from the dense Staffordshire and Shropshire clays. The chief fault of these common tiles, which are often used for paving the floors of cottages and outhouses, is their great porosity. They absorb so much water that they are always cold and damp to the feet.

This defect is not so apparent in the tiles made from the blue clays (*i.e.*, those clays which, owing to the presence of iron, burn blue), which are much more suitable for paving purposes, though very unpleasant in point of colour. In many parts of the country it is customary to use the blue bricks and quarries for foot pavements; but owing to their almost metallic surface, it is necessary to roughen them artificially to render them less slippery. Mr. Page, the engineer of Westminster Bridge, was so struck with the hardness and durability of the blue ware, that he employed 12-inch blue tiles for the foot pavements of the bridge; but they do not seem to have answered his expectations, as they have now worn away so much as to have lost every trace of their blue colour, and in some places have become very uneven. This is rendered all the more conspicuous by the occasional insertion of strips of granite, which stand out a quarter of an inch and more above the tiles.

Under the heading of flooring-tiles, we may also allude to the so-called Dutch clinkers, which are largely used for paving purposes. They are in reality a species of small, hard-burnt bricks, generally made from the gault or some similar clay, and employed for the interior of stables, for which, owing to their great hardness and imperviousness, they are admirably fitted.

Even so far back as the latter end of the thirteenth century, the art of making inlaid tiles or tiles which received their decoration from the insertion of a pattern in coloured clay, seems to have been practised in this country. The pavements of many old halls and churches appear to have been formed of such tiles, many of which evince great skill and care in their manufacture. The revival of the art of making these tiles—which seems to have been lost or to have fallen into abeyance—is due to an English manufacturer, Mr. Herbert Minton, of Stoke, whose name is now invariably associated with "encaustic" tiles.

Before going further we may explain briefly what we take to be the meaning of the term "encaustic." We understand such materials to be truly encaustic, as have the various colours they display actually intermixed with the substances or clays from which they are formed, and burnt in, as it were, at the same time as the article is fired: a combination, in fact, of coloured "bodies," as the clays in this state would be termed. Tiles formed thus by inserting for a considerable depth, or throughout their entire thickness variously-coloured clays disposed in certain definite forms would be true encaustic tiles.

In opposition to such tiles, we have what are known as "decorated tiles," or those which have on a plain surface, a pattern printed in one or more colours. These tiles have thus all the appearance of true encaustic tiles; but they have, of course, no such qualities of wear. They are therefore used for wall tiles, hearths, etc., and for places where there is no traffic. They are very commonly passed through the gloss-oven, where they receive an ordinary fritted glaze. In some of these pseudo-encaustic tiles, small bands of colour are printed round each of the edges, to represent the depth of the insertion of the coloured clays in the real tiles. A third description of tiles is known as majolica tiles, and here the clay receives a moulded or enriched surface in the biscuit state, and is then passed through the enamelling kiln and enriched with various opaque, glazed colours technically known as "enamel colours." These tiles, of course, are used solely for wall-tiling.

Having thus explained the various kinds of tiles, we may pass on to a more detailed account of the processes of their manufacture. The clay used for what we may call the foundation or body of an encaustic tile, has to be very carefully selected and prepared. We have already noticed in various other places, the manner of dealing with the clay in order to fit it for use, and in describing the mode of manipulating the clay for tile-making in detail, we should have to repeat much of what has been said previously. The principal seat of the tile manufacture is, of course, in the vicinity of the Staffordshire potteries, and the clay mostly used is the red surface clay of the district, and the buff-coloured clay or marl. For those tiles which are required to be of a pure white colour, or which it is proposed to stain of a delicate tint, it becomes necessary to use the more expensive white clays of Dorsetshire and Devonshire.

The clays undergo almost the same nicety of preparation for tile-making as would be observed in the case of pottery. The raw clay is first subjected to the action of the blunging mill, which consists of a set of long cutting-knives like the teeth of a gigantic rake. These knives are inserted into a horizontal shaft, which is caused to revolve slowly in a pan or tank about half full of water. The action of these knives is to tear and beat the clay to pieces, and to mix it with the water to the consistency of a thinnish cream. This cream, technically known as "slip," runs away by natural overflow to the evaporating pans or "slip kilns," and the heavier and more solid impurities in the clay sink to the bottom of the blunging mill, whence they may be from time to time withdrawn. In the condition of slip, any mixture of clays or introduction of colouring matter can be admirably and thoroughly effected. For some processes in the manufacture of encaustic tiles, as we shall see later, the clay is used either as slip or in a butter-like state; but for the ordinary pressed tiles it is used slightly damp as a powder.

The slip-kiln, till recently in common use for drying or evaporating the water from the clay, consists of a number of parallel, horizontal flues, covered with fire-clay quarries, and having a furnace at one end, and a lofty chimney at the other, in order to promote a sufficient draught. The floor of the slip-kiln is surrounded with a brick margin, raised about twelve inches above it, and is laid at such an incline that, while at the end nearest the furnace where the heat, of course, is greatest, the liquid slip when first run on is about 7 or 8 inches in depth; at the far end near the chimney the depth is not more than from 2 to 3 inches. It is found by this means that the whole of the clay is ready to take off about the same time. Slip-kiln builders have several fanciful regulations about the size of their flues, which they decrease very rapidly at the end of the kiln furthest from the furnace, deeming that in this way they produce a sharper draught into the chimney, the only actual result being that the flues very soon get filled up, owing to their shallowness, with the leakages through the joints of the cover-quarries. The time required to evaporate a charge of slip on an ordinary-sized kiln is from seventeen to twenty hours, and the clay is considered ready when it is all in a soft putty-like condition. A long slip-kiln requires careful management, as the clay is very liable to become partially caked and unfit for use, owing to its being overdried at one end before the other is ready.

Slip-kilns will, however, soon be entirely superseded by the patent clay presses or wringing machines, introduced by Messrs. Needham and Kite. By means of this invention the liquid clay is run into a number of linen cloths folded into a series of bags, and inserted between fluted boards placed in a frame. These boards are gradually driven together by hydraulic pressure, and the water in the clay is expelled through the pores of the linen wrappers; thus in a very short time the clay is dry enough for use, and when prepared in this way it is said to be better than that which has been boiled. Were it not for a heavy royalty now charged under the patent, and the great wear and tear in the cloths, this process would doubtless be universally employed by potters. For the manufacture of the clay-dust, however, the wringers alone are insufficient, as the whole of the water must be expelled by means of kiln-drying, before the clay can be ground. The dried clay is pulverised under horizontal stones, and if necessary dressed through a fine sieve.

The almost impalpable powder obtained in this way is now ready for use. As it comes from the mill it is not quite damp enough to bind, and in order to moisten it equably and sufficiently, a curious process is now adopted. It was found that no system of sprinkling with water or other artificial mode of wetting it rendered it all equally damp. Advantage has therefore been taken of the sponge-like action of plaster of Paris. Large beds, some four or five inches in thickness, of this material are prepared and carefully wetted; on these beds an even layer of clay-dust is spread previous to its use, and this clay sucks up from the damp plaster exactly the proper amount of water to give it the required cohesion. From these beds, the clay is carried to the presses, which are cumbrous affairs, made much after the fashion of coining presses, having a screw to which is attached the lid of the mould and heavy arms to cause the revolution of the screw. The mould itself, made of course of metal, is formed by a depression in the otherwise level surface of the table on which rests the clay. The workman begins by scraping across into the mould enough of the powder to fill it, and roughly levels the surface by striking it with a straight-edge. The screw or die is then brought down gently at first to expel the air, after which a sharp and heavy blow is given by rapidly swinging round the arms of the screw. By this second blow the clay in the mould is reduced to about two-thirds of its former thickness, and is so far consolidated that it can readily be moved about and handled. The mould is relieved by an upward motion of the plate forming the bottom of it, worked by a lever-handle at the side of the press. On bringing this plate back to its former position, the mould is again ready to charge with clay for the formation of another tile; the entire process occupying far less time than we have taken to describe it. For small tiles and diagonals or angle-tiles, a divided mould making two at a time is commonly employed. A press on a very much smaller scale and worked by girls is used for making in exactly a similar way, the encaustic tesseræ for mosaic work.

Of course, by using dust stained in various colours, while the clay is in the state of slip, tiles or tesseræ of any self tint can be obtained by this process, and tiles made of pure white clay-dust are in general use for decoration, either by transfer printing or painting. Before the tiles can be decorated, they must necessarily be burned into the state of biscuit, which is effected in "ovens" of the kind commonly used for burning pottery. These ovens may be described in a few words, as follows:—Round a circular chamber which may be from 14 to 16 feet in diameter, are arranged a series of fire-places or "fire-holes," varying from eight to twelve in number. These fire-holes communicate with the oven by means of flues passing under the floor to an orifice in the centre, and small vertical chimneys built against the inner wall called the "bags." These ovens may be from 14 to 20 feet in height, and are covered in at the top with a brick dome pierced with openings (generally three to each fire-hole) to carry off the products of combustion. A fierce upward draught is produced by surrounding the entire oven with a flask-shaped chimney. This chimney, from the fact that its width at the base is such as to enable the workmen to attend to the fires under cover, is called the "hovel." The goods to be fired are enclosed in oval boxes of fire-clay called "seggars," to protect them from the flames which freely enter the oven through the floor and bags. Some tile-makers have introduced seggars of a square form which can be better filled with tiles than the round or oval boxes, but are said not to last so long. These seggars when filled are placed one above the other in stacks, sometimes twenty-five seggars in height, called "bungs." In firing a biscuit oven, the usual precautions are taken to raise the heat very slowly, so that the goods are "smoked" for many hours before the full firing, which lasts about forty-eight hours, is commenced. All tiles have to be first fired in the biscuit oven, and for plain encaustic tiles, this is the only firing required.

SHIP-BUILDING.—VIII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF IRON SHIPS (*continued*).

It will be remembered that in remarking on the framing of wood ships considerable importance was attached to the use of diagonal riders; and in the earlier days of iron ship-building many proposals were made to employ similar strengthenings in iron ships upon the inside of the frames. These proposals were based upon an entire misconception of the relative capabilities for resisting strains of the skins of the two classes of ships, and they have never found much favour with practical builders. The planking of a wood ship is made up of numerous narrow strakes, almost destitute of edge-connections, and very liable on that account to sliding of edge on edge when any change in the longitudinal form takes place; consequently, diagonal ties are in them most important auxiliaries. The plating of an iron ship, on the contrary, is made up of comparatively broad strakes, strongly riveted to each other at the edges, and forming a combination which is capable of resisting and transmitting strains in all directions, without any aid from diagonal ties. In other words, the edge-riveting of the strakes of outside plating in an iron ship does in a much more efficient way that which the diagonal riders are intended to do in a wood ship—viz., to prevent changes in the relative positions of the various strakes in the skin, and to increase the rigidity and strength of the structure.

Reverting to our comparison of ships to girders, we may contrast the conditions of wood and iron ships more readily, and further illustrate the statement just made. In the wood ship's girder, for the upright position, the web, between the upper and lower flanges, would be formed of the planking on the sides, as we have said, of narrow strakes imperfectly connected to each other. When subjected to strains, such a girder might obviously bend without developing the full strength which it would have if the web, instead of being made up of several layers badly joined, were formed in one piece; for in the latter case the web would greatly aid the flanges, whereas in the former the flanges would have to act almost alone, and the layers in the web, instead of acting together, would probably slide upon one another. Any means, therefore, of increasing the *rigidity* of the web, must lead also to a gain in the strength of the girder; and in preventing the sliding of layers in the web, diagonal braces strongly fastened to the various layers would be of great service. The transverse frames, as was previously explained, are not capable of opposing this change of form, and consequently diagonal riders must be used in wood ships. Nor can the transverse frames of iron ships oppose similar changes of form; but in them the strakes of outside plating are so strongly riveted to each other at the edges as to form what is almost equivalent to a web made of one piece, and possessing such an amount of rigidity as to enable the flanges to develop their strength satisfactorily. No one would propose to add diagonal strengthenings to the web of a girder if that web were made up of one piece; and similarly it would be most unwise to dispose material in the form of diagonal riders in an iron ship, seeing that the skin-plating really constitutes one well-connected mass. These remarks are made here rather than in our farther description of the skins of iron and wood ships, because the use of diagonal strengthenings is so closely connected with the arrangements of the framing.

Attention will next be directed to the "diagonal system" of framing iron ships. This has not been commonly adopted, but it has been made use of in the construction of several vessels, and therefore merits notice.

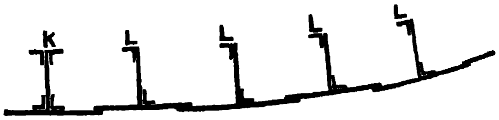
The frames used in this system consist of frame angle-irons, reversed frames, and floor-plates, just as the ordinary transverse frames (shown in Fig. 20, page 150) are formed. Instead of being placed in vertical transverse planes, however, the frames are inclined to the vertical at an angle of about 45 degrees, and consequently would appear in a profile view of the ship so built, just as the diagonal riders of a wood ship appear in the elevation, Fig. 15, page 81. In some vessels built on this plan the frames on one side slope forward throughout the length, and those on the other side slope aft. The deck-beams, also, instead of being placed transversely, are arranged diagonally, those belonging to the different decks being made to cross one another, and in many other minor respects common arrangements are departed from. As a consequence of the diagonal positions occupied by the framing, it is found advantageous to make the butts of the outside plating also diagonal, or parallel to the frames, and in every way it is attempted to substitute diagonal for transverse or vertical lines of weakness.

The aim of all these departures from ordinary methods is obvious. Under the action of longitudinal bending strains, an ordinary iron ship is more likely to fail at a transverse section passing through a line of rivet-holes in wake of one of the frames, than at any other section. The originators of the diagonal system, starting from this fact, have aimed at so disposing the material used for stiffening the skin, as to make it impossible for a ship to break across at any transverse section of the outside plating, without also breaking across the frames, beams, etc., which cross the line of fracture of the plating. In other words, they have sought to remedy the great defect of the transverse system of framing already pointed out—viz., the inefficiency of the main frames against the principal bending strains to which the ship is subjected. And to some extent they have succeeded. For example, the lines of riveting of the plating to the frames are no longer in transverse planes, but in diagonal lines, and therefore less likely to be followed by the fracture. Presuming, as seems probable, that the line of fracture will be more or less closely in a transverse plane, it will be evident that several of the diagonal frames will cross that line, and lend their strength to the plating, requiring to be broken across before the entire separation of the parts before and abaft could be effected. The same idea, doubtless, has led to the beams being placed diagonally, but the gain of strength which follows is much less important.

Against these advantages must be set some grave disadvantages. First of all, the diagonal system leads to much more complicated and costly workmanship than is required by the transverse system. It appears also that, although the diagonal framing does lend some aid against longitudinal strains, there still remains a necessity for employing internal keelsons and stringers similar to those used in ordinary iron ships. Diagonal frames, moreover, have this disadvantage as compared with transverse vertical frames, that they are heavier and necessarily tend to droop at the upper extremities, being retained in their inclined positions only by the support of the outside plating. For these and other reasons ship-builders have never favoured the use of this system, but have preferred to employ the transverse system, which can be so reinforced by longitudinal strengthenings as to answer well in even the largest merchant ships. In fact, with equal weights of material it appears possible to give a vessel almost, if not quite as great strength against longitudinal strains by framing her transversely and putting in good keelsons and stringers, as by framing her diagonally. Even with diagonal frames longitudinal strengthenings would be used, and the saving in weight obtained by using transverse instead of diagonal frames would aid in giving increased longitudinal strength to the vessel built on the ordinary plan. Apart from this, however, there are the important considerations of cost and simplicity of construction, both of which are greatly in favour of the transverse system, and these have, no doubt, been the chief causes of the non-employment of the diagonal system.

Turning next to the longitudinal system of framing, we meet with an arrangement which well combines simplicity and strength, and is likely to be more extensively used when the necessity for following out in practice the true principles of construction becomes more pressing. At present the transverse system of framing can be made to answer even in our largest merchant ships; but it has the great defect of leaving to supplementary strengthenings the work of succouring the outside plating against longitudinal strains, while the greater portion of the weight of material used to stiffen the skin is available only against transverse strains. In the longitudinal system the conditions are entirely reversed. The main frames are effective against longitudinal strains and are all directly connected with the plating they are intended to assist, while the transverse framing is made to occupy a subordinate position. Such a change could not be expected to find favour at once, involving as it did a departure from long-used methods, and even now the longitudinal system is but seldom used by private ship-builders. It has been used, however, by its author, Mr. Scott Russell, in several of his ships; the *Great Eastern* is so constructed; and the system of construction used in the armoured ships of the Royal Navy is in some respects an outgrowth from the longitudinal system. Facts such as these are, we think, sufficient testimony to the merits of this plan of building, which without further preface we will attempt to describe.

Fig 22.



In Fig. 22 is shown a transverse section of a portion of the framing of a longitudinally-built ship. It will be seen that there is no external keel, but what has been described as a "flat-plate" keel; upon which stands a vertical keelson, or keel (K), formed of a plate with double angle-irons on both edges. This keelson would be continuous throughout the length of the ship, the butts of the several lengths of plate and angle-iron used in its construction being carefully shifted from those of the flat-keel plate, and secured by well-riveted straps. Each of the strakes of plating is supported by a longitudinal frame or girder (L) formed of a plate with a single angle-iron on each edge. These plates would, of course, be varied in depth and thickness according to the size of the vessel, as would also the dimensions of the angle-irons. The butts of the plates and angle-irons would also be carefully shifted and strapped; and in the former operation regard would be had not merely to the butts of the particular girder or frame, and the strake of plating to which it was secured, but also to those of the other longitudinals, in order to avoid any specially weak cross-section. The longitudinals stand square to the plating at every section, so that the angle-irons on their edges are not bevelled; and as a consequence the surface of the plates is "twisted." The greater number of these frames would be continued right forward to the bow, and to within a short distance of the stern of the ship; but some of them would be stopped short at sections more or less distant from the extremities where the girth of the vessel becomes much less than it was amidships. At the stern, transverse framing is often employed for a small part of the length, as there are special advantages gained by this arrangement in portions where the vessel is very fine; in some cases, however, the longitudinals extend quite to the stern-post.

Only a portion of the vessel's section is shown in Fig. 22, but it illustrates the great features of the arrangements that would be made at least up to the height of the lower deck. Slight variations, of course, would occur in different vessels. For example, a builder might not fit a longitudinal frame on every strake of plating, but on only every other strake; and in the *Great Eastern* herself only the strakes near the middle line, which have to bear the strains consequent on the ship taking the ground, are thus individually supported, the longitudinals coming on alternate strakes at other parts. The parts of ships lying above the lower decks are not usually framed longitudinally, sufficient strength being obtained from plating laid on the deck-beams, as we shall endeavour to explain fully hereafter.

The simplicity and efficiency of this system cannot fail to be remarked. It provides ample longitudinal strength by means of the strong girders directly connected with the outside plating, and crossing the probable lines of fracture at right angles. In an earlier paper it was remarked that by placing two thin plates of iron at right angles to each other, and securing them in that position by connecting angle-irons, it was possible to form a strong T-shaped girder out of plates which apart could not sustain their own weight without bending between the points of support. Here we have this simple principle practically applied. The thin bottom plating, which would bend or buckle readily if unsupported, is effectually stiffened by the longitudinal frame, also formed of a thin plate with angle-irons attached. When a ship is subject to hogging strains, the lower part is brought under compression, and if there are intervals of comparatively unsupported plating, as there would be in a transversely-framed ship without numerous longitudinal strengthenings, the plating will be very liable to fail, not by direct compression, but by *bending* or *buckling* between the frames. The thinner the bottom plating is made, the greater is the danger of buckling, and the more need is there for efficient longitudinal stiffeners; but no fear need be entertained on this account, even with the thinnest plating, so long as such a system of framing as is shown in Fig. 22 is employed.

This matter has an important bearing on the probable future use of steel in ship-building. Steel has not, as yet, been largely used, but there is every reason to anticipate its more general employment when its manufacture has been somewhat improved. At present ship-builders feel some distrust in using it, because it is not of so certainly uniform a quality as might be wished; but when this objection is removed, as it doubtless will be, the obvious gain by using the stronger material in place of iron will probably lead to its extensive employment. Good iron plates will bear a tensile strain of from 20 to 22 tons per square inch of sectional area, whereas steel plates of good quality, as now made, will bear a strain of more than 30 tons to the inch, so that being half as strong again as the iron, the steel plating of a ship need only be two-thirds as thick, or as heavy, in order to give the same strength against tensile strains. Against compressive strains tending to buckle the bottom plating, the thinner steel plating would need longitudinal stiffening even more than the iron plating, and it may be reasonably anticipated, therefore, that when steel ships become more common, the longitudinal system of framing, or some modifications thereof, will come into more general use. It may be interesting to add that professional ship-builders who have inspected the steel blockade-runners built in this country during the Civil War in America, have reported that it was a common thing to see the bottom plating slightly bent, or buckled, between the transverse frames—a fact which entirely bears out the opinion expressed above.

Provision being made for the longitudinal strength by the arrangements shown in section in Fig. 22, other means are required to give the necessary transverse strength. These are of a very simple character, and need but a brief description. Mr. Scott Russell relies largely upon the transverse bulkheads to supply transverse strength, and fits as many of them as the service for which the ship is intended will permit. His rule, where the plan can be followed, is to have the ship subdivided into compartments of which the length is not greater than the vessel's extreme breadth, but this cannot always be done. The bulkheads, being formed of plates well stiffened by angle-irons, constitute almost rigid partitions in the hold, and the strength thus obtained is transmitted to the parts lying between them by means of the longitudinal frames. In some cases, and we believe the *Great Eastern* herself is an example in point, the bulkheads are almost entirely relied upon to supply transverse strength to the structure; but in other cases, where the bulkheads are comparatively far apart, transverse framing of a special character is fitted in the intermediate spaces. These transverse frames—or, as Mr. Russell terms them, "partial bulkheads"—are usually about 12 or 14 feet apart; and made up of short pieces of plate, fitted between the continuous longitudinals (L, L, L, L), and connected with them by pieces of angle-iron. The outer edges of these plates are connected with the bottom plating, and on their inner edges there is a single reversed angle-iron, worked like the plates in short lengths.

In the *Great Eastern* a water-tight iron skin is fitted upon the inside as well as the outside of the longitudinal frames, and so a "double bottom" of a cellular construction is formed. The advantages in point of safety gained by this arrangement have been already illustrated, and the importance of thus constructing iron ships has been urged. Double bottoms also add greatly to the strength of the lower portions of iron ships; for experimental researches made in connection with the design of the tubular bridges over the river Conway and the Menai Straits, showed conclusively that with wrought iron the cellular construction was best adapted for resisting compressive strains. The cost of construction is, of course, increased by having double bottoms, and there is a decrease in the internal space available for stowing cargo; but it seems a questionable policy to set these disadvantages above the advantages just referred to, especially as they may be associated with a moderate total weight of hull, after including the material in the second skin.

The principal objections urged against the longitudinal system by the advocates of the transverse system, are the greater cost of construction it entails, and the fact that it leaves considerable spaces of the bottom plating without direct support against local strains. Taking the latter objection first, it must be admitted that there is some force in it, although its importance may have been over-estimated. In a ship such as that illustrated by Fig. 22, for example, it would be possible to find spaces where the bottom for a length of 12 or 15 feet and a breadth of 3 or 4 feet would have no direct support, being framed in, as it were, by the longitudinals and the partial bulkheads; and where no partial bulkheads are fitted these unsupported spaces would, of course, be much longer, although not broader. Local strains, such as follow upon grounding or striking some fixed hard body, would be most injurious in their action on these unsupported spaces, and on this account the introduction of more closely-spaced light transverse framing seems desirable. It will be shown hereafter that in building the iron-clads of the navy this is actually done, and with a small expenditure of material the bottom plating is well supported.

The remaining objection, additional cost of construction, is no doubt a true one at present, because of the fact that nearly all iron ships are transversely framed. Greater acquaintance with the longitudinal system would, however, undoubtedly reduce the cost of building very considerably, and make it compare more favourably with the transverse system. One thing is certain, that the necessary strength can be given to an iron ship with a less expenditure of material when she is built on the longitudinal system than can be done when she is framed transversely; and this saving in weight, adding as it does to the vessel's cargo-carrying power, must make her future service more remunerative. Continuing at work for twenty or thirty years, and having during all that time the power of carrying, on the same draught, say 100 tons of dead weight more than if she were built on the old plan, a ship longitudinally framed may in the end prove the cheaper, although her first cost may be greater. From the commercial as well as the structural aspect of the case it appears desirable, therefore, that improved methods of construction should be more generally adopted.

SEATS OF INDUSTRY.—XXIII.

PHILADELPHIA (*continued*).

BY WILLIAM WATT WEBSTER.

At Girard College, already mentioned, 340 boys are supported and educated on a foundation estimated at 8,000,000 dollars. This magnificent institution, unequalled in the United States, was endowed by a Philadelphia merchant named Stephen Girard, who did much to promote the commercial prosperity of the city. By his will this worthy forbade the appointment of any ecclesiastic, missionary, or minister, to any office in connection with the college, and even ordered them to be refused admittance within its precincts. Another part of his deed, however, directed that care should be taken "to instil into the minds of the scholars the purest principles of morality," and from this it has been inferred that Girard did not intend to exclude the Bible from the curriculum of instruction, and the directors have considered themselves justified, under this clause, in binding the president to have family worship morning and evening, and to perform regular religious services twice every Sunday, either personally or by some competent lay deputy. There are three medical colleges in Philadelphia, with an aggregate annual attendance of about 1,500 students. The university of Philadelphia, founded in 1755, occupies a large building originally built for the President of the United States, and is chiefly distinguished as a medical school, but in addition to its faculty of medicine, it has faculties of arts, natural science, and law, and it has also attached to it a junior academy and a charity school. It possesses valuable philosophical apparatus, and a considerable library. The oldest seminary in Philadelphia was incorporated by William Penn under the title of the Friends' Public Schools. It is a wealthy institution, and supports a number of schools which give instruction in Greek and Latin, mathematics, and natural and mental philosophy. The astronomical observatory of the city belongs to this institution, and it also possesses valuable philosophical apparatus. In addition to the educational establishments already noticed, there is in operation in the city and county of Philadelphia, a comprehensive and highly efficient organisation for imparting education to the people under the administration of a school-board. This system includes a high-school, where ancient and modern languages, mathematics, mental, moral, natural, and political science, drawing, &c., are taught by a principal and ten professors; and grammar, secondary, and primary schools. The average annual attendance at these schools is estimated at about 50,000, and the expense at about £40,000. There are some 400 female and 100 male teachers employed in the schools. Among the principal libraries and literary and scientific institutions in the city, are the Philadelphia Library, established by Franklin in 1731, which occupies an elegant marble edifice, and possesses considerably more than 70,000 volumes, a museum and philosophical apparatus; the American Philosophical Society, established in 1769, which has a library of about 22,000 volumes, and a valuable museum, and which has published several volumes of Transactions; the Academy of Natural Sciences, comprising a library of about 13,000 volumes, and a cabinet of natural history, believed to be the most complete in America, and particularly rich in birds, of which there are some 25,000 specimens; the Athenæum, incorporated in 1815, which occupies a fine building in the Italian style, and has a library of upwards of 10,000 volumes, and a reading-room, where the principal European and American newspapers and a large selection of European and American magazines are to be found; the Pennsylvania Historical Society; the Franklin Institute, for the promotion of the mechanical arts, and an Academy of the Fine Arts with a gallery of 1,000 pictures. Of the numerous charities the most noteworthy are the almshouses on the banks of the Schuylkill, consisting of four distinct ranges of buildings containing nearly 4,000 rooms; the Pennsylvania Hospital, established in 1752, one of the finest institutions of the kind in the United States, attached to which are a valuable anatomical museum, a library, and a handsome building erected in 1817 for the accommodation of Benjamin West's picture of "Christ healing the sick," the exhibition of which is a highly profitable source of income to the hospital; and the United States Marine Hospital, for the maintenance of invalid officers and sailors of the navy, besides various liberal and extensive institutions for the deaf and dumb, the blind, fallen women, orphans, etc. The Volunteer Fire Department of the city is 3,000 strong. Besides twelve banks of issue, there are fifteen savings banks in Philadelphia, and an extraordinary number of benefit societies. The hotels of Philadelphia are very extensive establishments. It is doubtful whether any American metropolitan city contains a larger or more beautiful hotel than the "Continental," which covers an area of 41,536 square feet, comprises a main hall 185 feet in depth, contains over 100 complete suites of family rooms, and requires 280 servants in various capacities. There are six excellent markets in the city, and the streets are traversed by tramways in all directions, the number of cars amounting to about 500, drawn by about 3,000 horses. The city is divided for municipal purposes into twenty-four wards, and is governed by a mayor, twenty-four select council-men, and ninety-five common council-men. Philadelphia sends seven representatives and two senators to the State Legislature.

The commerce of Philadelphia is very extensive and has been rapidly increasing. In the rivers Schuylkill and Delaware it possesses the advantage of a double port; the former, being the shallower, is set apart for the domestic or internal trade, and is the grand depôt for the coal and petroleum of the Union; and the latter, having water to float the largest merchantmen close to the quays, is exclusively resorted to by vessels engaged in foreign trade. To show the vast and rapid increase in the coal trade of Philadelphia, it may be stated that in 1825 only 5,306 tons were brought to the city by the Schuylkill, whereas thirty years later the quantity of coal sent down by the same channel amounted to about 3,000,000 tons, exclusive of twice as much supplied through other routes. A large quantity of this coal is exported from Philadelphia to other ports in the United States. The exports of petroleum from Philadelphia have made extraordinary progress. In 1863 there were shipped at the port but 4,930,708 gallons, valued at 1,382,082 dollars, and in 1867 the quantity had increased to 28,751,445 gallons, valued at 8,053,233 dollars. Besides coal, petroleum, and iron, the principal articles exported from Philadelphia are wheat and wheaten flour, Indian corn, and other agricultural products. The imports consist principally of cotton, woollen, and silk goods; sugar, coffee, and tea; iron and hardware; wines, brandies, spices, dye-stuffs, etc. Philadelphia ranks fourth among the ports in the United States in point of shipping, being inferior only to New York, Boston, and New Orleans. In 1865, 531 vessels with an aggregate burden of 159,579 tons entered the port. The foreign trade is small compared with the home or coasting trade. In 1866 the exports were valued at 17,913,901 dollars, and the imports at 14,115,004, being several millions of dollars in both cases less than they were valued at ten years previously. Philadelphia is fast becoming an important manufacturing as well as commercial city, the annual value of its manufactures being now upwards of 175,000,000 dollars. This city has gained a reputation in America for its shot, nail, cotton, paper, rope and glass manufactories, and it is the largest publishing emporium in the United States. Besides large quantities of books, there are printed in Philadelphia 13 daily, 4 tri-weekly, and 46 weekly newspapers; 44 magazines and periodicals, 30 of which are weekly; and 2 daily and 3 weekly papers in German.

TECHNICAL DRAWING.—LX.

GOTHIC STONEWORK.

PERPENDICULAR ENGLISH PIERS

Are sometimes simple octagons in plan, as in the preceding styles, but these are not so frequent as before. Clustered piers occur very often, their general form being that of a square set diagonally. An example of these is given in Fig. 495, p. 113, in order that it may be compared with those of the two preceding styles.

PERPENDICULAR ENGLISH CAPITALS AND FOLIAGE.

The capitals are either circular or octagonal, but the necking is usually the former, and the upper members of the abacus almost invariably of the latter form. The bell portion is mostly plain, but is often enriched with foliage of an exceedingly conventional character. It is shallow and formal—without either the freedom and boldness of the Early English, or the natural grace of the Decorated period, and with a certain squareness of outline which the eye soon detects.

We frequently find the tendrils, leaves, and fruit of the vine carved or sculptured in great profusion in the hollow of rich cornice mouldings. The example (Fig. 519) here presented will illustrate this. It is taken from the west doorway of Beverley Church, Yorkshire. The base mouldings are usually set upon a lofty polygonal plinth, which is sometimes double, the lower one projecting, and the projection moulded with a hollow or reversed ogee. In clustered piers the bases are mostly treated separately, as is the case with the capitals; but sometimes the mouldings are continued all round, as are also the plinths.

PERPENDICULAR ENGLISH ORNAMENTS.

One of the most distinguishing features in the system of ornamentation of this period is that called "panel-tracery" (Fig. 513), with which the walls and vaulted ceilings of buildings are almost entirely covered. The patterns were formed by mullions and tracery resembling windows, and a variety of other panels of different forms, such as circles, squares, quatrefoils, etc., are profusely used in subordinate parts, which are enriched with tracery, featherings, foliage, shields, etc., disposed in various ways. A very rich description of vaulting was also frequently used, composed of pendant curved semicones, covered with foliated panel-work, called "fan-tracery," from the design resembling a fan spread open.

Another very general ornament of this period is the Tudor flower (Fig. 514). This ornament is formed of a series of flat leaves, placed upright on the stalk. It was very much used late in the period, in long suits as a crest or ornamental finishing, on cornices, or in forming a beautiful enriched battlement. The examples differ considerably in detail, but the general effect is nearly the same in all.

Cornices and brackets were frequently ornamented by angels' heads, with shoulders, wings, and arms. These are called Angel-brackets, and Angel-corbels.

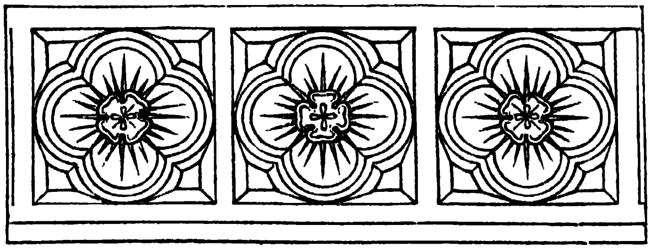
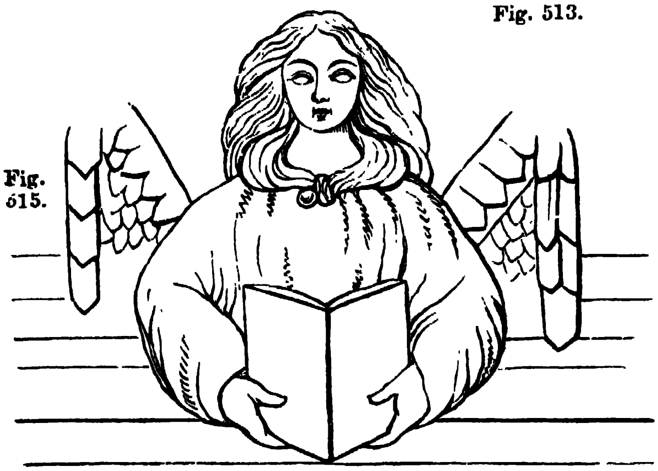


Fig. 513.

Fig. 515.



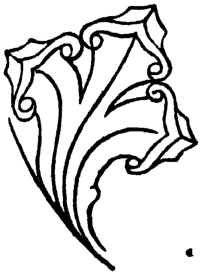
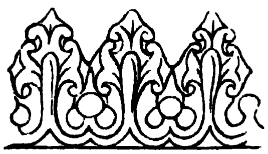


Fig. 518.

Fig. 514.



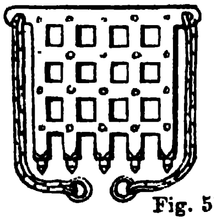


Fig. 516.

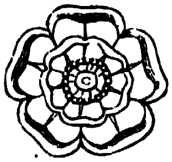


Fig. 517.

A great number of edifices (says Rickman) of this style appear to have been executed in the reign of Henry VII., as the angels so profusely introduced into his own works are abundantly scattered in buildings of this style. Fig. 515 is part of an angel string-course from St. Mary's Church, Oxford.

The Portcullis (Fig. 516) and Rose (Fig. 517)—both badges of the Tudors—were constantly carved as ornaments.

The crockets (Fig. 518) belonging to this style for the most part partake of the squareness which pervades all the foliage, and in a few instances animals and figures were used for this purpose.

The buttresses are, as far as the plain ones are concerned, similar to those of the preceding style, but are sometimes finished with a crocketed pinnacle. In richer examples the faces are covered with panel-work, and are finished with square pinnacles sometimes set diagonally and terminated with a crocketed spire, or finished with an animal or such-like ornament.

Parapets with square embattlements are very common at this period, but they are also frequently panelled or pierced with tracery in quatrefoils, or trefoils inserted in square, circular, or triangular compartments. The cornice is often composed of several mouldings, divided by rather shallow hollows, in some of which flowers of square form are placed at intervals, and in others figures or grotesque animals (as at Mold Church, Flintshire) are introduced.

The towers are frequently on a grand scale, and are often devoid of spires, though frequently surmounted by a lantern, and sometimes by four little turrets placed at the angles. The towers of some of the churches of this period are in some cases almost entirely covered with panel-work-as that at Wrexham, Denbighshire. Towers of this period are very numerous; amongst the best are those of Canterbury, York, and Gloucester Cathedrals, and the churches at Boston and Louth in Lincolnshire; Kettering, Northamptonshire; Cirencester, Gloucestershire; Great Malvern, Worcestershire; Magdalen College, Oxford; St. John's, Chester, etc.

The gradual decline of the Gothic style is very evident in the later churches of this period, especially in those of the beginning of the sixteenth century. It will be easily understood that the Reformation was for a time a bar to the revival of this style and the introduction at the same period of classical architecture, called the Renaissance, whilst the elements of the Gothic, though much degraded, were still in existence, led to that mixture of features, and that incongruity of style which followed, and which has been called the Debased Gothic, in which every real principle of art and of beauty was lost. It may be known by its general heaviness of design and want of elegance in detail—depressed archways and square-headed windows with perpendicular mullions, the heads of the lights often without foliation. It is chiefly found in repairs and alterations made between 1540 and 1640; but some few specimens of good work, especially of fan-tracery, are to be found. In Italy the Gothic was at once superseded by the Classical; but in other countries it waned into forms which have been termed "After-Gothic," which gradually merged into the Revived Classic. Within recent years a revival of the Gothic has taken place in this country, and buildings have been, and are being, erected, which will well bear comparison with those of the Middle Ages: We have architects too, who, in their knowledge of scientific principles of design and construction, and whose enthusiasm in their vocation, have never been surpassed in any country or period; and, further, we have mechanical appliances for working stone and iron, and for building purposes generally, never equalled—but *we want educated workmen.* In the Middle Ages, architects, as distinct practitioners, were scarcely known, and little more than the general arrangements of a building were designed by them. The rest lay with the workmen, who, working in bodies, largely influenced the beauty and appearance of the buildings. Their spirit was in their work, and they were thus enabled to "stamp each stone with earnest feeling." It is with the view of aiding the workmen of the present day that these lessons are put forth, in the sanguine hope that they may be of service to them.

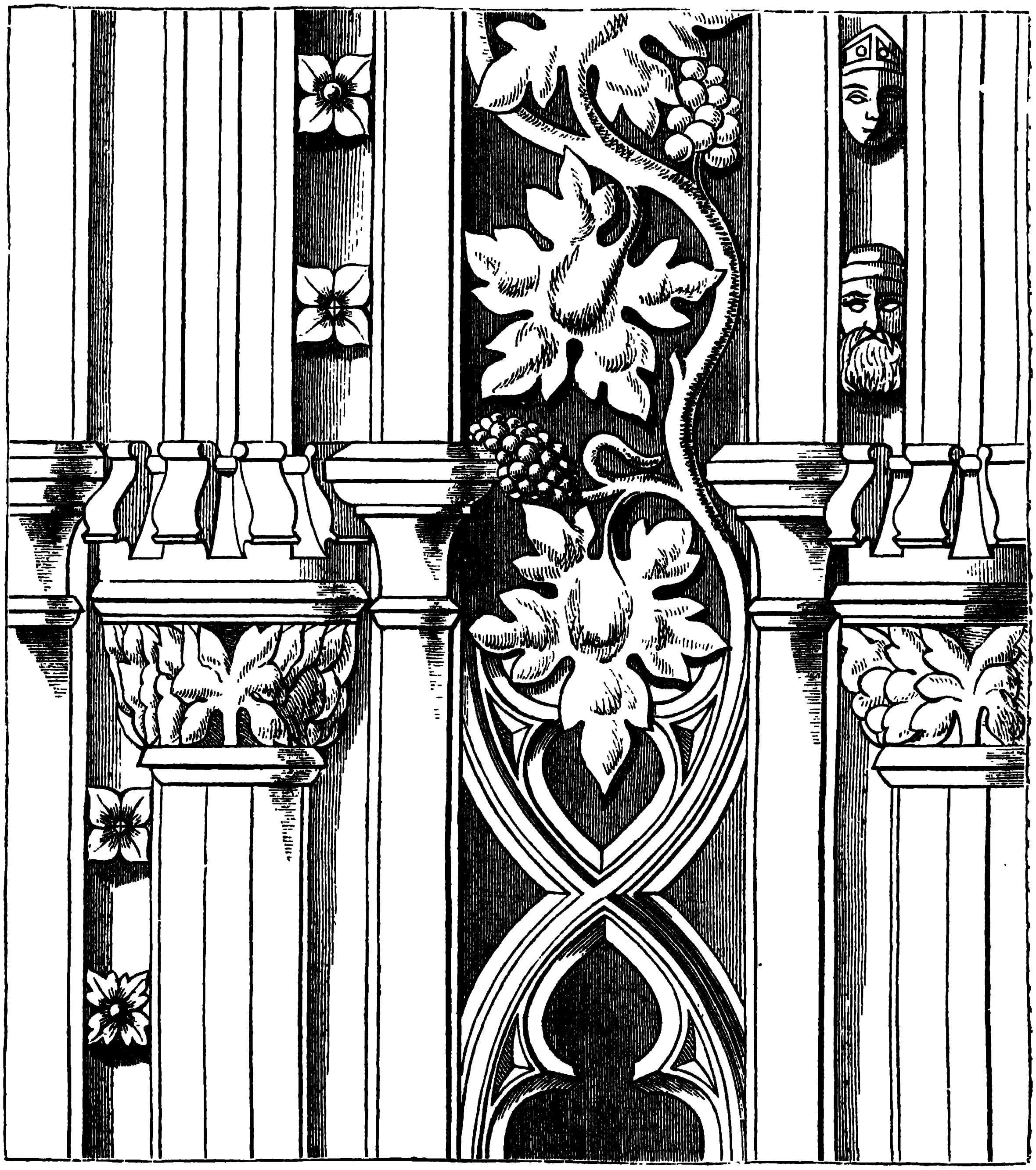


Fig. 519.—CARVING FROM THE WEST DOORWAY OF BEVERLEY CHURCH, YORKSHIRE.

GLOSSARY OF SOME TERMS USED IN GOTHIC ARCHITECTURE, IN ADDITION TO THOSE EXPLAINED IN THE TEXT.

Abacus—Derived from the Greek word signifying a tray or flat board. The slab forming the upper part of a column, pier, etc.

Abbey—A term for the church and other buildings used by those conventual bodies presided over by an abbot or abbess, in contradistinction to a *cathedral*, which is presided over by a bishop, and a *priory*, the head of which was a prior or prioress. The word is generally supposed to have been derived from the Hebrew *ab*, "father," by which name the abbot was generally designated.

Almery, also Aumery, Aumbrie, and Ambry—A recess in a wall of a church, sometimes square-headed and sometimes arched over and closed with a door like a cupboard, and used to contain the chalices, basins, cruets, etc., for the use of the priest: many of them have stone shelves. They are sometimes near the piscina, but more often on the opposite side. The word also seems in mediæval times to have been commonly used for any closed cupboard, or even bookcase. In fact the word *armoire* is applied to such objects to the present day.

Angel-Lights—The outer upper lights in a perpendicular window, next to the springing. It is probably only a corruption of the word "angle-lights," as they are nearly triangular.

Arcade—A range of arches supported either on columns or piers, and detached from or attached to the wall. The word is used in contradistinction to colonnade, which is a range of columns carrying level entablatures.

Bay Window—Any window projecting outwards from the wall of a building, either square or polygonal in plan, and commencing from the ground. If they are carried on projecting corbels they are called *oriel* windows. Their use seems to have been confined to the later periods. In the Tudor and Elizabethan styles they are often semicircular in plan, in which case some think it more correct to call them *Bow*-windows.

Belfry—Properly speaking, a detached tower or campanile containing bells, but more generally applied to the ringing-room or loft of the tower of a church.

Bell-cot, Bell-gable, or Bell-turret—The place where one or more bells are hung in chapels or small churches which have no towers. Those which stand on the gable dividing the nave from the chancel are generally called Sanctus Bells.

PHOTOGRAPHY.—V.

By J. C. Leake.

FAILURES IN EARLY ATTEMPTS: THEIR CAUSES AND REMEDIES.

It is hardly to be expected that the first attempt to produce a negative will be perfectly successful, even if the utmost care has been exercised in all parts of the process previously given, and we will therefore proceed to classify the failures most likely to occur, and to offer suggestions as to their causes and remedies. The defects most likely to be met with in making a negative are, first, a general clouding or fog over the whole plate after the application of the iron-developing solution; and, secondly, marks, stains, or spots in various parts of the picture. Of these the first-named is by far the most difficult to trace to its proper source, as it may arise from various causes, oftentimes from that which might be least suspected. Thus, an exposure of undue length in the camera will produce an effect of fogging which, to the inexperienced operator, might at first appear to be the result of improper chemical action, while a similar defect will result if the plate has received the slightest trace of white light during its preparation, or through an unobserved crack or hole in the camera or slide. From whatever source the defect arises, however, it must be overcome, or the resulting pictures will be flat, and deficient in light and shade, or brilliance.

If care be taken in conducting the following experiments, it will be easily ascertained by the operator from which direction the difficulty arises, and then as easily remedied. We will suppose that upon the application of the iron-developing solution the picture flashes out almost instantly, and is thin or veiled, all the details being equally developed over the whole surface, but without density and brilliance. In this case the exposure has probably been too long by at least one-half. Reduce this when trying another plate, and observe the result. If the fogging is still present while some of the detail in the shades of the picture remain undeveloped, the cause is probably diffused light either in the darkened room or in the camera. Shut out the whole of the light from the laboratory, and prepare a plate by the aid of a small candle, carefully surrounded with several thicknesses of yellow paper or calico. Insert the plate in the slide as if for exposure in the camera, and when it is enclosed allow the yellow light to enter the room through the prepared screen. Now draw up the shutter about an inch, and allow the yellow light to fall upon the exposed portion of the plate for about five minutes. Develop as usual. If any trace of an exposure is to be observed, the light is too strong, and extra thicknesses of yellow paper or calico must be added, in order to exclude it. When this test is concluded, prepare a plate in the same manner, and place it in the camera, drawing up the slide, but not removing the cap from the lens. Allow the plate to remain at least five minutes. If on development any spots of light appear, or the plate is fogged, there is probably a small hole or defect in the camera, which must of course be stopped. This is a cause of failure which often remains undetected—in fact, unsuspected—for years, and one which cannot be too carefully attended to and remedied. Should there still be signs of fogging, it may probably be now traced to the chemicals employed. If the collodion is newly iodised, and used in a bright light, it will frequently exhibit this defect, especially if it be perfectly colourless. Drop into the mixed collodion enough alcoholic tincture of iodine to reduce the mixture to a very pale sherry tint; should this fail, add to the nitrate-of-silver bath pure nitric acid, in the proportion of one drop to the pint of solution. After these additions allow the solution to rest at least three or four hours, and there will, in all probability, be no further difficulty from this cause. It should always be remembered that in working in the open air, or with portrait lenses of large aperture, it is of the utmost importance to keep the glasses shielded from the light, either by means of a fixed shade, or by holding a light board or card over them. It often happens that a very slight mist or fog in the atmosphere will, even if almost imperceptible to the eye, produce a very decided fogging upon the plate, and this must, of course, be allowed for in all test operations.

The other class of failures we have mentioned—namely, markings and spots of various kinds—are very much more easily traced to their causes, and will give but little trouble to the operator, if he will only take proper care in observing their character. Of these defects that most frequent is the presence of transparent spots of various sizes, giving the effect of holes in the collodion film. These most frequently arise from dust in the collodion or the nitrate bath. Always allow the collodion to settle for some hours before pouring it into the working bottle, and be careful that no dust is allowed to enter the bath, or to adhere to the sides thereof, when the solution is poured in. Sometimes small portions of the collodion film become detached from the plates during the sensitising process, and after floating in the solution, attach themselves to the sensitive surface when the plate is removed, of course shielding it from the action of light in the camera, and producing transparent holes of their own shape and size. To remove these the bath solution must be frequently filtered, and before commencing operations each day any scum or dust should be removed from the top of the solution. Spots with an opaque centre, or completely opaque, frequently occur when using a new camera, from the contact of small particles of metal left in the slide. All the parts of the camera and slides should be most carefully washed before use, and the joints well brushed out. Too much care cannot be expended in keeping all the solutions well filtered; and this being done, failure from spots will be of rare occurrence. Another cause of failure arises from imperfect coating of the plate with collodion. If this be not properly effected the film will be of various thicknesses, and, consequently, more density will be observable in one part of the finished picture than in others. This defect will generally be more apparent in the lower or last-coated portion of the plate than at the top, in consequence of the evaporation of the solvents leaving the collodion thicker in that part than in the other. In warm weather this frequently becomes a source of considerable difficulty, and the only remedies are the use of a collodion containing a rather larger proportion of alcohol than usual, and a rapid and dexterous coating of the plate, in order to reduce the evaporation to a minimum. The irregularity of the film is, however, easily observable before sensitising, and when it is likely to be of importance, the plate should be rejected before inserting it in the nitrate bath. Cloudy markings are also frequently caused by an improper application of the developing solution. This should be applied from the lower edge of the picture, and should flow in a perfectly even wave over the surface, sweeping and carrying away with it a little of the silver solution, which will have drained down to what was the lower edge of the plate during exposure. The developer should not be allowed to rest upon the plate, but be kept flowing in all directions, so as to become most intimately mixed with the nitrate of silver solution. Should this precaution be neglected, irregular development will result, and stains will be made which will spoil the picture. It is also necessary to use so much alcohol as will cause the developer to mix at once with the silver solution in the film; and it must be remembered that as the ether and alcohol accumulate in the nitrate bath this quantity must be increased, or oily markings will make their appearance from irregular action, the fluid being altogether rejected from some portions of the surface. Curved lines of over development sometimes occur, either from the use of a too concentrated solution of iron, or from the insufficient quantity of acetic acid present. In warm weather, or when the chemicals are in a very highly sensitive condition, and the light intense, double or treble the quantity given in our formula may be used with advantage. Straight lines traversing the film in the direction of the surface of the bath are caused by checking the plate while it is being immersed in the solution. The dip must be made at once, and without the slightest hesitation; hence it is advisable to make use of a bath considerably larger than the plate itself, in order to prevent its catching at the corners. Wavy lines running from the top to the bottom of the plate are caused by the trickling down of the nitrate solution during the exposure. The plate must be well drained before insertion in the dark slide of the camera, and not laid flat or be reversed in position until its removal for development. It is a good plan to lay a slip of clean white blotting-paper in the slide under the plate, which will absorb any solution which may flow to the lower edge; of course a fresh slip will be required for each plate. It sometimes happens that lines make their appearance in the direction of the dip. These are often due to some slight imperfection in the bath, and the addition of nitric acid before mentioned will mostly remove them. If not, reverse the position of the plate upon the dipper, and keep it in constant motion during the sensitising process. Observe whether the lines extend to the top of the plate, and are straight, or only about half-way across, and are irregular. In the latter case either the bath is weak in silver, or the collodion has not been allowed sufficient time to set before immersion in the solution. The remedies in both cases are obvious.

We have before treated of the effect of over exposure of the plate in the camera, and we now come to that of under exposure. Of the two evils, that of over exposure is the least, and the most easily overcome, as by a little skill in development the effect of over action of light may be considerably reduced, and a tolerable picture obtained. In the case of insufficient action, however, nothing whatever can be effected, and any considerable forcing of the development will only render the picture more hard and offensive in an artistic sense. The test of proper exposure is that of development of detail in the darkest shades of the picture, and it is only when this is obtained that the work can be said to be perfect. If upon the application of the iron developer the image appears tardily, and is weak and metallic, the details at the same time being thin and poor, it may at once be considered that the action of light has been insufficient. It often happens that the operator does not sufficiently consider the quality of the light he is working with, or the character of the subject he is photographing. For instance, the time we have given for exposure in a former chapter would be ample in that particular instance, while in a close lane, or in a forest, the time must be trebled, or more than that. The remedy for this defect can at once be seen, and on no account should an under-exposed picture be allowed to pass. Sometimes, however, the effect of under exposure is produced from an improper condition of the chemicals, as, for instance, depression of temperature, the use of a decomposed collodion, or a weak and disordered nitrate bath. In the first case warm all the solutions to forty or sixty degrees. This will often effect a change as if by magic, and the pictures will develop well and rapidly. The next case is not of frequent occurrence, as bromo-iodised collodion will, if properly treated, keep almost an indefinite time. It is advisable, however, in cold and dull weather not to mix too much at once, as a freshly-iodised sample will mostly work more rapidly than an old one. In the third instance add silver to the solution, in the proportion of ten grains to the ounce; and this failing, mix a ten-grain solution of carbonate of soda, and add to the nitrate of silver solution until it is quite turbid. Filter at least twice, and add one drop of nitric acid. In all probability this will remedy the defect; but it must be remembered that no amount of exposure or of skill in manipulation will make up for bad light, and that, consequently, where the best results are required, the weather must be favourable and the light good. It is scarcely to be expected that the operator will meet with all the causes of failure which we have here enumerated, but we have mentioned these in order that he may be prepared to meet any difficulties which may arise. We should advise that all failures be met in detail, and remedied one by one; when, having been once overcome, the operator will have no further difficulties. We may now consider that a perfect negative has been produced, and will in our next paper proceed to describe the processes by which the positive prints upon paper are produced.

p. 20

OPTICAL INSTRUMENTS.—XVIII.

BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

After critically weighing the value of the various safety arrangements described in the preceding papers, I believe I have hit upon a contrivance that will make the oxy-hydrogen apparatus perfectly safe for amateurs if they will but use it properly. This is described in a paper I read before the Photographic Society, February 8th, 1870.*

Highley's Interceptor (Fig. 72) consists of a brass cylinder water-chamber, closed by a screw-cap lid, through which passes a brass ingress-pipe, I, that is connected by a flexible tube with the gas reservoir. This inlet-tube is fitted with a "ball-valve," B, or a "lip-valve," L, or both, so as to allow the gas to pass in one direction only; and like Gurney's arrangement, it passes to the bottom of the cylinder, so that the bubble must rise through some three or four inches of water, before it can escape by an egress-pipe, E, screwed into the lid, that is connected by a flexible tube, T, with one of the stop-cocks, S, of a mixed gas jet, as shown in the figure. The ingress-tube is made somewhat conical inside, and the upper end is partially closed by a semi-circular dome, D, that corresponds to the diameter of a small india-rubber (or hollow metal) ball. When the gas passes from its reservoir into the ingress-tube, it drives the water before it, and the ball to the angle of the tube, where it is stopped at its widest part, to allow of the gas passing round it and on to the lip-valve, from whence it passes through the water, out by the exit-tube, on to the nozzle of the jet J. Should there by any accident or mismanagement be a greater pressure on one bag than on the other, then the gases will be driven back down that tube of the jet connected with the reservoir that is insufficiently weighted, and on to the interceptor, the water in which cannot pass the lip-valve unless it be out of order, in which case the water would rise in the ingress-tube, I, and the float-ball would be carried upwards till blocked in the dome, D, of the ball-valve, when the further passage of gas or water towards the jeopardised reservoir would be stopped; or should the weights be entirely removed from one bag, then a "suck-back" action would take place as soon as the bag, etc., was lightened, but the ball would then be sucked upwards towards the dome, and again stop the way. As Gurney's safety chamber was used in connection with one reservoir containing the mixed gases, the contingency of unequal pressure was not provided for. As we never know on which reservoir unequal pressure may arise, both must be fitted with an interceptor, as shown in Fig. 72, and the impossibility of an explosive mixture being found *in the reservoirs* in any dangerous quantity will be self-evident.

The Oxy-hydrogen Jet, wherein the two gases stored in separate reservoirs are mixed in a small chamber just before they issue from the nozzle, is usually constructed on the type shown in Fig. 73. Two separate tubes for conveying the oxygen and hydrogen from their respective reservoirs are brazed into a cylindrical chamber, wherein the gases are combined in proper proportion, by regulating the stop-cocks fitted to the end of each tube. The lime-cylinder is adjustable to and fro by means of a spring stage *that slides* between the two delivery tubes, and is rotated, raised, or depressed by means of a pin sliding in a spring tube. Sometimes the mixing chamber and sometimes the tubes are filled with Hemming's safety arrangement. When great pressure is to be used, as when the gases are delivered from stout, heavily-weighted gasometers, etc., or the condensed gas-bottles, the ordinary lime-pin must be removed, and the cylinder must be mounted on a "lime-clock," so that instead of being turned occasionally by hand, it may be rotated automatically with a constant upward motion, for the following reason—viz., if only turned from time to time by hand, the limes would soon "pit" and throw the point of light out of proper focal adjustment with the optical arrangement; for so great is the pressure obtainable with the condensed gas system, that I have seen a spiral groove cut in hard limes, even while rotated by clockwork. If such a jet of ignited gases were left on one spot for a few minutes, the lime-cylinder would most probably crack and fall to pieces, and consequently cause interruption to the lecture or exhibition, or the ignited jet might be deflected from the pitted cavity back on to the condensers of the lantern and crack them. If, on the other hand, the lime rotated *downwards*, the top of the cylinder might descend below the nozzle before being noticed, and then a long pointed jet of the ignited gases would shoot over it and strike the back of the lantern, and if made of wood might set it on fire; whereas if the lime works *upwards*, a proper adjustment of jet can be made with the upper end of the cylinder at starting, and then such an accident is provided against. Moreover, any cracks are left above the jet. Such are the usual arrangements of the oxy-hydrogen jet; but considering the accidents and shortcomings the travelling lecturer has to provide against, I have designed a system that I term the " convertible jet." As it may be used with a lime-clock for high pressure or with a hand-rotating lime-pin (best suited for "soft limes," which should not be frequently turned) as an "oxy-hydrogen jet," should one of the gas-bags break down, it may then be connected with the gas main, and be used as a "oxy-house-gas jet." Should neither house gas nor pure hydrogen be forthcoming, then instead of being placed *hors de combat*, it may be used as an "oxy-spirit jet," so that it may be converted from one arrangement to the other, according to requirement and the will of the operator. This contrivance was described in a paper on "Lantern Construction" read before the Edinburgh Photographic Society, April 7th, 1869, and published in the *British Journal of Photography*, May 21st, 1869.

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* See *Journal of the Photographic Society*, No. 214, Vol. XIV., page 208.

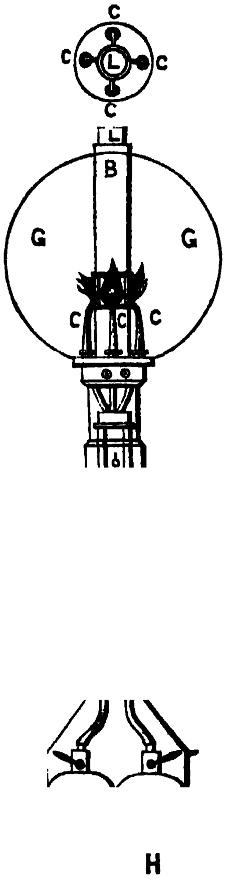

Fig. 71.

Highley's Convertible Jet.—Commencing with the supporting-rod and clamp, I think I may safely say most workers must have experienced the difficulty of firmly clamping any ordinary form of burner or jet—that has, through its length, much leverage—on to the thin rods usually attached to the lamp tray. To overcome this serious defect, I tried larger rods and powerful clamps made on the French method for telescopic joints, but with slight advantage, till I hit upon the simple plan of filing away the side of the supporting-rod opposite the thumb-screw, so that two sharp edges were left to bite on to the adjusting rod, as shown in Fig. 74; R being the rod, T the sliding tube working over it, and S the clamp-screw. The main portion of the jet is shown in Fig. 75; S being a sectional side, and T a top view of the disposition of the oxygen (O) and hydrogen (H) delivery-tubes, the stop-cocks, nozzle, supporting-rod R, and clamp C. The gas-tubes are free from all impediments of safety dodges, as I prefer a clear gangway, that allows of the nozzle or tubes being freely got at if accidentally clogged with dust, etc., and putting my dependence for safety on constant and equal pressure, as previously advocated. The mixing chamber is a modification of the arrangement previously shown in Fig. 63, page 124. The tube that carries the nozzle pulls off, so that coarse or fine bores can be fitted according to the amount of pressure to be employed or special arrangement selected. The bore of the nozzle, in relation to the pressure employed, is a matter of importance in the proper construction of a jet; for if too large, the gases run back and burn within the nozzle tube, often causing a series of sharp explosions, which, if not dangerous, are unpleasant to the ears of a nervous exhibitor or of the audience.

Fig. 76 shows the ordinary arm for supporting the lime-ball L, whether the "convertible jet" is employed for the "mixed gas" or "oxy-house-gas" arrangement. The lime is supported by a pin, P, long enough to hold two limes, as shown in Fig. 77, for the purpose of keeping a reserve lime warm and ready for action, should the one in use crack; and is adjusted by a screw-pin, S, the support being clamped between the gas-tubes, H, O, by a nut, N.

Fig. 77 shows a lime-clock supported for the lime-ball L, that replaces the ordinary arm, if great pressure is to be used, especially when the condensed gas bottles are to be employed. This is one-half the size of the ordinary or old lime-clock, and is worked by a spring and cog, instead of the catgut action. K represents the key of the lime-clock; and, to facilitate winding up without disturbing the adjustments of the jet, the clock is supported on a little tray, T, that is clamped by a nut, N, between the gas-tubes, H, O, so that it can be removed bodily from the lantern; the tray allows of the lime being adjusted nearer to or further from the nozzle for producing the best light attainable.

Lime-tongs should be employed for the removal of hot cracked lime-cylinders.

Fig. 78 shows in section the spirit-lamp reservoir R, with the double wick, W, and the lime and support, L, S, with the air-way, F F, for keeping the reservoir cool, that has been described in detail in the previous papers on this subject, and likewise can be adjusted and clamped by a nut that slides between the gas-tubes, H, O. When this oxy-spirit jet is used, the stop-cock of one tube is closed, the other being connected with the oxygen reservoir; that gas being then projected from the nozzle on to the lime-cylinder.

Fig. 79 shows this jet with the lime-pin in position for connection with a house supply, and a bag of oxygen weighted with 56 lb. or with both gases in reservoirs each weighted with 112 lb., and fitted with an arrangement that allows of the lime being turned from outside the lantern, so as to avoid the necessity of constantly opening and shutting the side door as is the case when the lime is turned by hand. This is effected in the following manner:—It will be observed that the lime-pin, P, is attached to a stout tube, F, that can be worked by a female screw, upward or downward on a coarse-threaded male screw, S, fixed to the clamp, fitting with sufficient range to present in turn the entire surface of the lime-cylinder to the nozzle J. To the tube F a small drum, W, is fixed; a similar drum, *w*, *works up and down* on a screw cut on the clamp-tube T, that slides over the supporting-rod R: a cord wound round the drum W, can be unwound by the rotation of the drum *w*, and thus give the necessary motion to the lime from the back of the lantern. To secure a sufficient change of position from the spot where the ignited gases previously fell, without having to look at the lime itself, the head of the drum *w* is made square, as shown in the figure at *a*: all that is required is to turn round a flat face of this square, till that which was at the back stands to the side, and so on, every time the lime is seen to be pitted. This arrangement to a great extent obviates the necessity for lime-clocks, a matter of consideration when jets are intended for abroad, where it is not always possible to repair such delicate arrangements. The contrivance here described is not likely to get out of order, but if so, it can readily be repaired, supposing always that the apparatus is *substantially* made in the first instance, and not in a cheap and therefore almost worthless manner; for it must always be borne in mind that the best workmanship always proves the cheapest in the long run, and there is a wonderful difference between any article being really cheap or simply low-priced. This remark especially holds good with such objects of manufacture whereon human life may depend, whether it be a gun, a steam-boiler, or a gas-jet.

Lime-light Jet for Spectrum Demonstration.—The spectra of many bodies may be shown by fusing small quantities of material

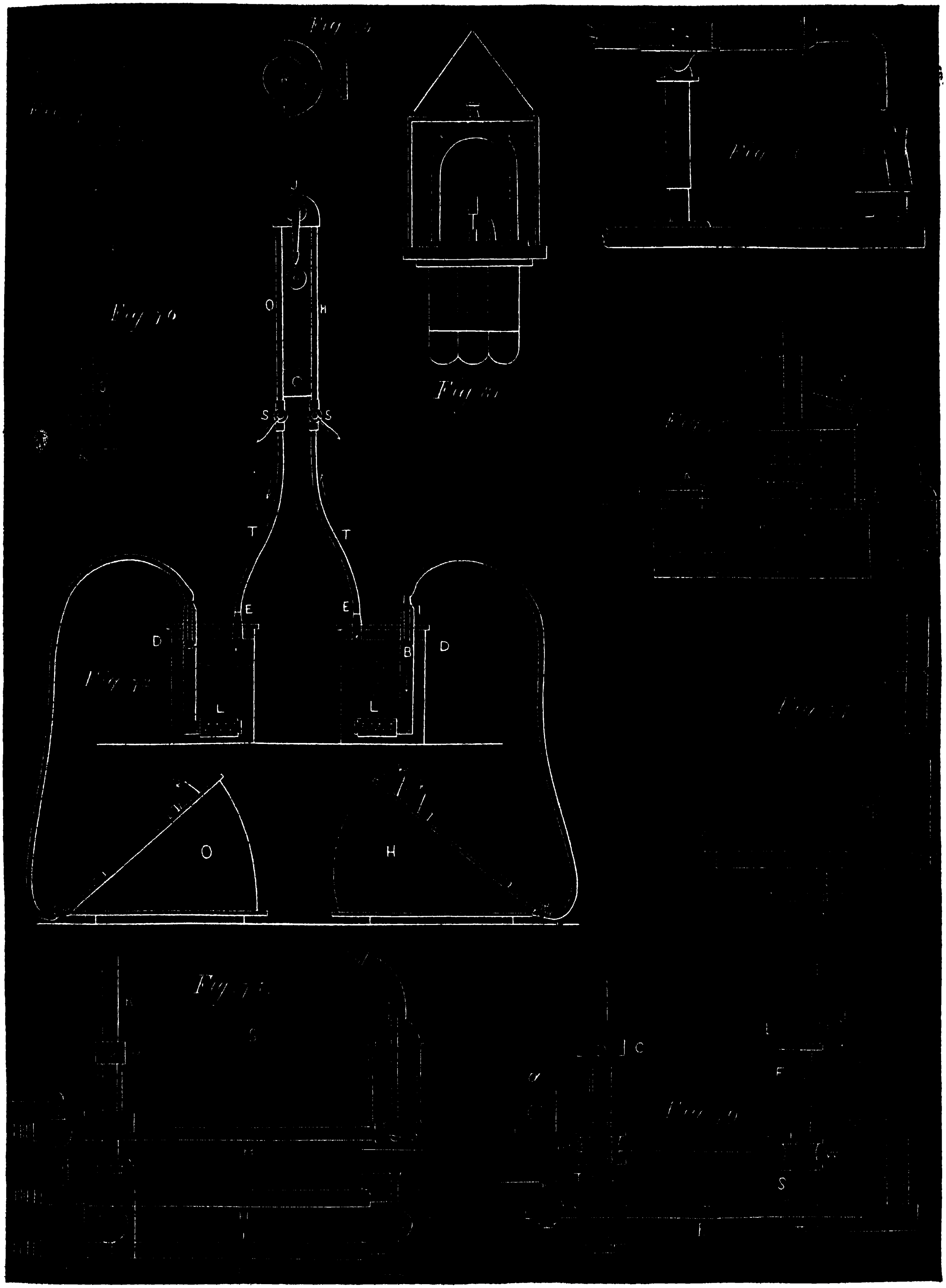
Fig. 76
J
O
H
C
S
S
T
T
E
E
D
B
D
L
L
O
H
Fig. 81
C
F
S

in a cup-shaped cavity worked in the top of a cylinder of lime, on which the oxy-hydrogen jet can be directed, when placed in the focus of a spectrum arrangement. The form of jet suited for this purpose is shown in Fig. 80. This may often be used when the expense and trouble of fitting up the electric lamp would be inconvenient.

Lime-light Lamp for Illuminating Museums, etc.—A strong feeling is growing up that our public museums should be opened at night for workmen and others who are confined to business during the day, and the question has been several times discussed in Parliament. Unquestionably any system that involves the distribution of gas-piping over public buildings intended for the conservation of scientific or artistic treasures, is objectionable, on grounds quite distinct from the question of probable injury to pictures, etc., through fire; for in case of a conflagration, a train of fire is laid by means of the gas-pipes to extend the mischief, even though care may have been taken to guard against extension. How often has it happened (especially at our theatres) that the provisions made against fire have not been accessible or are out of order just when they were really needed. The cheapest and safest light that could be employed for lighting scientific museums, and most probably art-galleries also, would be a lime-light lamp, wherein the jets were fed by pure dry hydrogen and oxygen condensed in the bottles previously described at page 123, Fig. 61. A suitable form of standard lamp I designed for this purpose is shown in Fig. 71, the gases from four nozzles, marked C, fed from the bottles, H, O, impinge on an automatically ascending cylinder of lime, L, which is covered by a thin metallic guard, B, the light being dispersed by a large ground-glass "moon globe," G G. This arrangement can be placed in position, and removed at pleasure, and the gases being isolated, any accident, or extension of accident, would be impossible; for, as I have previously stated, any conflagration or explosion with such bottles is impossible, as could be readily tested at Woolwich or elsewhere. Each day the empty bottles could be replaced by fresh ones, and as they would be enclosed, under lock and key, in the case of the standard, none but an appointed attendant would have access to them. As the lime is simply rendered incandescent by ignited gases that give off no injurious vapours, and the process is not one of ordinary combustion, neither carbonic acid, sulphuric acid, nor sulphuretted hydrogen can be produced, as in the case of illumination by ordinary house-gas. The only doubtful question is, as to whether the sublimed lime vapour given off in *small quantities* during the period of ignition would in time exert an injurious influence on oil paintings, etc., as the lime would be slowly distributed in impalpable powder through the atmosphere unless carried off from a closed globe by a special contrivance. Such powder would be lime in a caustic state, and this moreover would "slack" in a damp atmosphere, so that a lengthened series of experiments would be necessary before this arrangement could safely be employed in a picture-gallery *with an open globe*. From a sanitary point of view this would be a good arrangement for public rooms; for as the incandescent lime takes all the oxygen it requires from the gas-bottles, it in no way abstracts oxygen from the air of the room which it illuminates, or leaves an undue proportion of nitrogen, as is the case with the ordinary combustion of house-gas or oil-burners, which, with carbonic acid gas, another product of their combustion, tend to establish a stifling atmosphere. Again, the heat from the lime-light speedily diffuses itself through the atmosphere in all directions, and is much less in proportion than that given off from a series of burners that would give an equal amount of illumination. As previously stated, were there a demand, both pure hydrogen and oxygen could be produced on a large scale at a very cheap rate.

Submarine Lights are employed for diving operations, attracting fish at fishing-stations, etc. Fig. 81 shows an arrangement devised by Mr. Sykes Ward. It consists of a series of condensed gas-bottles, connected with a lime-light jet, enclosed under a double glass shade, the outer shade being provided to keep the cold water from contact with the inner heated one. A few years since, I fitted up an electric regulator on a similar plan for a fishery company. In either arrangement an air-tube is not required, as the lights are not dependent on the ordinary process of combustion.

India-rubber Connections are requisite for joining the generators to the gas-reservoirs, or the latter to the jets. I find the red rubber flexible tubing more lasting and free from the unpleasant smell of the ordinary vulcanised rubber tubing—which is always unpleasant to handle—and is more pliable than the old-fashioned plaited tubing. When it has to be laid in places where it is subject to be trodden on, it should be used with a spiral wire core, as a preventive to the gas being pinched off, and the light put out. The *Scientific American* gives a method for rendering gas-tubes impermeable, and rendering any escape impossible. "This can be done by giving the tubing a thin coating of a varnish made by dissolving 1½ parts of treacle and 2 parts of gum arabic in 7 parts of white wine and 3½ parts of strong alcohol. The treacle and gum must first be dissolved in the beer or wine, and the alcohol must be added very slowly, constantly stirring the mixture, or the gum will be thrown down."

If it be necessary to connect pieces of tube so as to form greater lengths, this may be effected by "connecting-pieces" made of brass tube, a shade larger than the bore of the rubber tubing, their ends, on to which the two pieces of tube are sprung, being ribbed to secure a perfect fitting.

FISH CULTURE.—V.

By Greville Fennell.

ARTIFICIAL FISH CULTURE AT HUNINGUEN.

The importance of fish culture as a means of procuring cheap and wholesome food is now so universally recognised that we need make no apology for extending our articles on this subject, and noticing at as great a length as our space will permit the efforts that have been made, and are still making, by individuals as well as societies, to bring fish into a closer rivalry with butchers' meat than it has hitherto attained. Among other societies and places where experimental fish culture is carried on, we have already mentioned the grand French establishment of Huningen, but instead of giving the past history in detail of this important institution, it will doubtless be more acceptable to employ our limited space with the last accounts from that seat of pisciculture, which we extract from the petition of the German Fishery Association of 13th of February last, to Count Bismarck.

"An establishment for artificial fish culture was founded by the Emperor Louis Napoleon at Huninguen, on the Rhine, at a great expense, for the purpose of re-stocking the French waters. Up to the present year the establishment has hatched out a large number of fish eggs, and has distributed them, both to public waters and to private persons. Though the results, as far as is known to the Fishery Association, have not entirely corresponded with the great outlay, it nevertheless cannot be denied that the whole establishment, which is on an extensive scale, and rationally and properly managed, will be of great use to our rivers and waters. It is, unquestionably, in the interest of the German fishery to maintain this establishment, and make it over to a German management, whose object and calling must be the encouragement of fish culture, the increasing and permanent multiplication of fish in all the German waters, and, naturally, to specially care for the Rhine and tributary rivers. If the establishment and existing materials—based on the experiments which have been made in France, England, Scotland, Ireland, and latterly in Sweden and Norway, in this matter—are properly used and supported by the technical experience she can command for a scientific superintendence of the operations, Germany, rich in waters, but by its own fault poor in fish, would vie easily with other countries in the production of fish. To attain this it is necessary to reform our very deficient laws in this respect, to raise up an interest for fish culture, to give instruction and all possible protection to those who carry on such hatching establishments. The German Association recognising this, has undertaken the task, and hopes to be able to reckon on the support of your Excellency and the German Government," etc.

"The Rhine," says another petition from and to the same, "one of the most beautiful rivers in the world, is specially suitable, by many tributary rivers, for the production of the better fish—namely, the salmon—in great quantity and quality. Year by year the produce has diminished, and all attempts at fish culture—the check of close time and similar measures—can lead to no results as long as they are not introduced and really carried out by the whole territory of the river, and particularly at the mouths of the river. The states on the river's banks recognising this have entered into a treaty at Mannheim on the 27th November, 1869, on the common regulations of the fishery in the Rhine from Basle downwards. This treaty was laid before the representatives of the different states by the governments, and was everywhere, even in the Prussian Landtag, almost unanimously accepted, but was unfortunately rejected by the Dutch Lower House. In the discussions in Holland, the suitability and the necessity of the regulations for the protection of the fishery were acknowledged, even by many of the opponents of the treaty; but in this case it was repugnant to the unjustifiable pride of the Dutch to make restrictive regulations for Dutch subjects in consequence of a treaty with other states, and it was proposed to the government that the regulations of the treaty should be embodied in a law and again brought forward in this form. Hitherto, as far as the Fishery Association knows, this has not been done; and we therefore venture the request that your Excellency should urge this question through the German Ambassador, and demand of the Royal Netherland Government that it remedies the abuses which it has itself acknowledged, through participation in the above-named treaty. Should the Dutch continue to fish as they do in late years, as, for instance, drawing nets through the river with small steamboats, which entirely close it, and at times when the weak and half-sick salmon descend the river; when with them there is no close time and partial freedom of the river given—there can be no useful results to the Rhine fishery either from the establishment at Huninguen or the judicious administration of the water, and soon salmon will be found in the zoological museums on the Rhine, but no more in the Rhine itself," etc.

By a decree of his Excellency the Minister of Agriculture, we further learn that "the larger fish establishments of the province in the north can claim the public interest for themselves on the ground that they offer a valuable though not certain means of preserving the riches of those waters in valuable fish, or to restore them. For these reasons I am inclined to subsidise the establishments, as far as public means are disposable for the purpose; only such grants must be in a form and under conditions which in some respects ensure the intended common object. Therefore, the form to choose in preference for the State grant, will be that the greater quantities of the young—at least five months old—Rhine salmon, salmon, and trout, be obtained for a moderate price in the current year, to be turned out direct into the waters. The receiving and the turning out of the fish will be consequently confided to an expert. It is scarcely to be doubted that the management of the rearing employed, and particularly the sort of nourishment which will be given to the young fish on the spaces of the establishments, is of important influence in their power to maintain themselves when turned out in the waters, and therefore particular regard will be paid, on the reception of the fish and settlement of the price, to a judicious course in rearing."

There are other governments actively bestirring themselves in the practical development of fish culture, while England, admitted to be the most forward in its pursuit, is left without other support than that derivable from the purses and public spirit of private persons.

An important feature in the arrangements of the establishments at Huninguen may not be passed over. Courses of rough stones and a due quantity of weed only line the banks. Thus every stone becomes a means of shelter and concealment. The adult trout have submerged holes and crevices made for a like purpose. This provision we have often insisted upon in our trout streams, and even in our larger rivers; but for the most part so obvious a necessity in accordance with the nature and the habits of trout is strangely neglected. Thus, constant walking up and down the banks of a river in which there are no hiding-places for the fish will chase and distress the trout in the stream to an extent that will drive them into other more quiet waters, that have harbours of refuge, if they have any chance of escaping. There should always exist hiding-places, particularly for trout. Roots of trees, large stones, under the aprons of weir and mill tails, and even eel and rat holes are all places to which trout will rush when a sudden fall of water takes place or they are unduly disturbed. In a mill-tail on the Itchen, between Twyford and Bishopstoke, in which trout lay in abundance, the water was suddenly let off to about an inch in depth; the trout were seen dashing here and there while the stream was subsiding, and most of them made for the apron and the deeps below, but upon examining three holes in the sand in the centre of the bed of the river, four fish of above a pound in weight were found in one hole, and three in each of the others.

FARMING AND FARMING ECONOMY.—X.

By Professor Wrightson, Royal Agricultural College, Cirencester.

BEANS, PEAS, ETC.

Lawson describes eight varieties of field, and fourteen varieties of garden, beans. Restricting ourselves to the former class, we notice the following as among those most widely grown:—

The common Scotch, or Horse Bean, is almost the only sort cultivated in Scotland. The shape and colour vary with soil and climate. It is generally "slightly irregularly compressed, and wrinkled on the sides, and frequently a little hollowed or flattened at the end; of a whitish or light-brownish colour, occasionally interspersed with darker blotches, particularly towards the extremities; colour of the eye black; straw 3 to 5 feet in length; average weight, 62 lb. per bushel." "In a warm, dry summer, the sample is always more plump and white, particularly if the harvest is also dry, and especially if cultivated on a strong clay, and drilled instead of sown broadcast." The great diversity is also owing to a mixture of varieties, sown together, and recognised under a common name. That such a mixture exists is evident to any one who examines a field of these beans in full flower, when they will be seen to present an infinite diversity in colour. Such differences are sufficient to constitute varieties, and therefore the seeds are more likely to vary than if the flowers were all the same.

The common Tick Bean is held in the highest estimation in England. It is shorter in the straw, and the seed is smaller, more cylindrical, and more rounded at the ends, than the last. It is also better adapted to light soils. *Harrow Ticks* are still smaller and finer than common ticks, and besides these there are *Essex Ticks*, *Flat Ticks*, and *French Ticks*, which chiefly differ from common ticks in being suitable for special descriptions of soil.

Winter or Russian Beans constitute a well-defined variety, characterised by their hardihood, enabling them to stand the rigours of winter, their shortness of straw, fineness of grain, and early period of ripening. This variety was introduced into England in 1825, and is considered by some agricultural writers to be identical with the *Heligoland Bean* (Lawson).

Messrs. Raynbird, Caldicott, and Co.'s list of seed corn for 1871 indicates the following varieties to be in demand:—*Horse or Tick Bean*, weight, 64 lb. per bushel; hardy and prolific. *Cluster Beans*, early and prolific, and of fine quality, often weighing 68 lb. per bushel; straw short. *Early Mazagan Bean*, larger than the tick bean; stalk tall; requires good land, and is suitable both for garden and field culture; weight per bushel, about 58 lb. *Long Pod Bean*, stalk stout and tall, grain large; comes late to harvest. *Broad Windsor Bean*, extensively cultivated in gardens, may be grown as a field crop with advantage upon good land. *Winter Bean* may be sown in October, and will be ready for harvest by the end of July.

Besides these, Lawson describes *Pigeon Beans*, an early, prolific dwarf, and small seeded variety; *Purple Field Beans*, a variety resembling winter beans; and the *Alexandrian Field Bean*, which grows about the height of the common horse bean, but is later in ripening, and is of a dull reddish-brown colour.

Beans are suitable for stiff clay soils, excepting winter beans, which may be grown successfully on lighter lands. The Norfolk rotation may be conveniently lengthened and modified by introducing this crop into it. Thus half the barley land may be seeded with clover, and half with beans, the result being that the interval between clover crops is increased from four to eight years. In courses of cropping suitable for clay districts, beans always occupy an important place, very frequently preceding wheat, for which they are an excellent preparation. (See Rotation of Crops, Vol. II., page 261).

In some cases clay soils have been alternately planted with wheat and beans for a succession of years, and under certain circumstances such a course may be followed with advantage. These two crops are especially suitable for stiff soils, while root-crops cannot be advantageously cultivated upon them. Bean cultivation allows of a thorough system of inter-tillage. While, therefore, it enriches the land for wheat, it also allows of cleaning operations being carried on, and hence both the principal objects of cultivation are attained. Again, crops are to be looked upon as exhausting or renovating, according to the use that is made of them. Beans sold off the premises of course tend to drain the soil of its valuable plant-producing constituents, but if fed on the farm in the form of bean-meal, and returned to the land, the soil is benefited to much the same extent as by a turnip-crop consumed in yards. In this case, we should have a course of cropping suitable to the natural requirements of the land, while in the case of turnip-culture we should run into endless difficulties. The objects of the farmer should be to obtain the largest amount of produce with the least expense, leaving the land in the best condition; and such a system as the above would probably accomplish these objects, with the help of efficient steam tillage and a judicious use of purchased manures.

PREPARATION OF THE SOIL, SOWING, ETC.

In the case of winter beans, the wheat or oat stubble is grubbed, harrowed, and weeded. The weeds are carried off, or burnt and spread on the surface. Dung at the rate of from twelve to fifteen loads is carted and spread, and the land is ploughed 4½ or 5 inches deep. The beans are drilled in October, 2 to 2½ inches deep, 18 to 24 inches apart between the rows, and at the rate of 2½ bushels per acre. Should the land be clean, the preparatory work may be commenced with carting out manure on the untouched stubble. The cultivation of spring beans does not differ materially from that of winter beans, the land being similarly prepared and the seed sown as early in the succeeding season as convenient. Probably no crop has been cultivated in so many different ways as beans. To give even a brief description of each method would far exceed the limits of the present paper. We must therefore be content with little more than naming the principal ones. *Broadcasting* on an ordinary ploughed furrow is to be avoided as slovenly, and likely to end in the land becoming foul. *Broadcasting* on a ribbed surface —*i.e.*, a surface raised into smaller or wider ridgelets, or drills, either with a small ribbing plough, or an ordinary plough—is not objectionable, as the method allows of interculture. *Drilling* is perhaps the most widely-used method, the coulters being placed from 18 to 24 inches apart. Beans are well adapted for *dibbling*, a process already described (see under Wheat, page 86). In Norfolk the land is marked out with a drill, in rows 14 inches wide, and beans are dibbled along the tracks of the coulters at 4s. per acre. In Holderness, Yorkshire, the land is winter ploughed, and in spring so lightly harrowed that the furrows are not obliterated. Beans are dibbled, one in each hole, in every seam, or every alternate seam, or from 10 to 20 inches apart, and 5 or 3 inches apart in the rows, respectively. The cost of this operation is 6s. per acre. Beans are also *ploughed* in. They are deposited at the bottom of the furrow by the bean-barrow, which follows immediately behind, and is attached to, a plough. The beans may be thus sown in every furrow, in alternate furrows, or in every third furrow. No crop is more suitable for a mixed system of cultivation. Thus Mr. Morton relates how he grew carrots and beans in alternate rows for many years, with success. Cabbages and turnips may also be planted or sown between wide-drilled beans, and occupy the ground after the main crop has been harvested.

Beans are occasionally "blended" with peas, and also with vetches. Both plans are excellent, as the strong bean-stalk offers an excellent support to the weaker plant with which it is associated. In the case of peas we must use the common grey field variety, or, at least, some kind which will ripen simultaneously with the beans. Vetches intended for seed may be conveniently separated by means of a sieve after thrashing. During the droughty season of 1864, Mr. Mechi recommended beans to be cut as a forage crop and used as a green food.

AFTER-CULTIVATION AND HARVESTING.

The after-cultivation of beans should be vigorously pursued with both hand and horse hoes until the plant flowers, when working among them will do harm by knocking off the incipient pods. Winter beans are early ready for cutting, while spring beans are usually the last crop harvested.

Beans are ready to cut when their leaves fall. Cutting is effected by means of the reaping-machine or by the hook, and beans require a considerable time before they are fit to cart. The crop is rendered uncertain through the attacks of the black dolphin (*Aphis Fabæ*), which frequently devastates bean-fields. The only remedy is to cut off the tops, upon which the pest usually settles, and to carry them away and burn or bury them.

PEAS.

Peas are divided into classes according to the colour of their flowers. In the first division the flower is white, with white or bluish-coloured seeds, commonly known as garden peas. In the second we commonly find coloured flowers, and grey, dun, red, or speckled peas, commonly called field peas (Lawson). We have, therefore, here, as in beans, two sub-species, *Arvense* and *Hortense*, and there is also an intermediate class, *Arvense vel Hortense*. Among the numerous varieties recommended for field cultivation we name the following:—

Common Grey Field Pea.—A late variety often sown in combination with beans on strong land; very prolific; straw forms excellent fodder.

Early Grey Warwick, or Nimble Hog.—Pods often in pairs; length of haulm 2 or 3 feet; earlier than any other of our cultivated peas. Apt to burn up in dry seasons.

Grey Hastings.—Resembles the last; pods and straw are longer; ripens three weeks later.

Partridge or Maple.—Pods broad, and contain five to seven seeds of medium size, and of a yellowish-brown colour, speckled with darker brown, and with light-coloured eyes; average length of straw 4 feet. Earlier than the last variety.

Grey Rouncival, Giant, or Dutch.—The tallest, latest, and largest field pea; length of haulm 6 to 8 feet.

Winter Pea.—Hardy, standing the severest winters. Seeds very small and dark-coloured; straw about 4 feet long, small and hard. Ripens very early when sown in October, but is later than most other varieties if sown in March.

In Messrs. Raynbird's lists for 1871, *Early Dun*, *Winter*, *Maple*, and *Early Emperor* are varieties advertised for sale.

CULTIVATION, ETC.

Peas are more delicate than beans. They require a lighter soil, and grow best on lands of a calcareous character. They occupy a similar place in rotation with beans. A similar cultivation to that recommended for beans will be found equally suitable for this crop. Peas are sown in March, either by the drill or broadcast, on a ribbed surface. Occasionally they are sown broadcast upon an ordinary furrow, a plan to be deprecated, as causing land to become foul. About three bushels of seed is sufficient, and the distance apart between the rows will be from 10 to 12 and up to 16 inches. No crop is more uncertain than peas, and it is difficult to recommend any suitable manure for them except farm-yard dung. A case is recorded in which a great effect was produced by the application of 8 cwt. of gypsum and 4 cwt. of common salt to a failing crop of peas. This is scarcely to be wondered at when we remember the partiality of this plant for lime and limy soils.

As many as sixty-two bushels of common grey peas have been grown. Forty-eight bushels are a maximum crop in Essex; twenty-four bushels are a fair crop without manure, and twenty-eight a fair average with manure. In bad pea seasons, the yield will, on the best soils, not average twenty-four bushels per acre, while on the inferior classes it will not be more than ten or twelve bushels per acre (J. Hannam in Morton's "Cyclopædia").

We have endeavoured to present to our readers some of the main facts regarding the principal cultivated crops. The study of each of those crops might have been approached from a botanist's, a chemist's, or an economist's point of view; but the foregoing facts must commend themselves to the farmer's mind as important. The best varieties, the soil suitable, the place in rotation, the preparation of the land, the planting, after-cultivation, harvesting, preparation, cost, and produce of the crops are all essential, while questions of composition of botanical differences, etc., however interesting, must be looked upon by the farmer as of secondary importance.

Many other plants occupy a place in British agriculture, but the foregoing are those which are co-extensive with our country. We therefore leave the consideration of flax, hemp, hops, teazles, woad, madder, coriander and caraway seed, buckwheat, canary seed, etc., as scarcely forming an integral part of our farming economy.

FORTIFICATION.—IX.

BY AN OFFICER OF THE ROYAL ENGINEERS.

DETAILS OF WORKS.

It is obvious that the guns intended for the defence of a work must either fire over the parapet or through openings made in it; and until recently there have only been two arrangements by which this could be effected—viz., by embrasures or barbettes. Mortars were the only species of ordnance which fired their projectiles over the parapet without themselves being visible, and exposed to the enemy's direct fire. The invention by Captain Moncrieff of a special carriage, which enables the guns to fire over the parapet *en barbette* and yet to descend to a position of security behind it while being loaded, seems to combine the advantages of both these methods, with but few of their defects, and there can be little doubt that if some inexpensive arrangement can be devised, by which the ordinary field or travelling gun-carriages can be rapidly converted, so as to act on the Moncrieff principle, it will to a great extent supersede in field-works the other methods referred to.

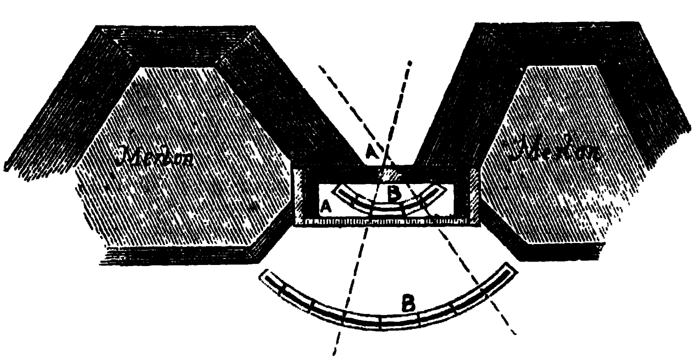

Fig. 62.—PLAN OF ONE GUN PORTION OF A COAST BATTERY, EARTHEN EMBRASURE, AND IRON SHIELD.

A, A, Shield and Supports. B, B, Iron Racers on Granite for traversing Gun.

Embrasures are openings made through the mass of the parapet, at such a level that the guns and gunners are completely protected from the enemy's direct fire, except such as may enter the work through the embrasure itself. To reduce the chance of this to a minimum, embrasures are made as small as is consistent with a sufficient lateral range for the guns, and the space that is necessary to prevent the destruction of the reveted sides or *cheeks* of the embrasure by the explosion of the charge. In the accompanying diagram (Fig. 63) the shapes of the various types of embrasures in earthworks are given, as well as the names and ordinary dimensions in feet and inches of the most important parts. Their general plan is a funnel-shaped opening, of just sufficient size at the *neck* to admit the muzzle of a gun (2 feet), and gradually widening outwards to allow of the gun being traversed through a certain horizontal angle. It is readily seen that the larger this angle is, the thinner and weaker the parapet becomes on either side of it; and the amount of protection afforded becomes very small indeed if the embrasures are very oblique to the parapet, or if the embrasure is necessarily large to enable the guns to follow with their fire objects moving rapidly past them. This latter is the case with coast batteries, and it has been found so impracticable to strengthen the weak points of embrasures of this kind by any ordinary means, that iron shields are almost universally adopted, in spite of their great expense. Embrasures are said to be *direct* or *oblique* when the centre line or directrix is at right angles, or oblique to the crest line of the work; and the terms *sloping* and *counter-sloping* are applied to indicate that in the former case the bottom of the embrasure or *sole* slopes downwards, to admit of the gun being fired at a depression, while in the latter the guns are only intended to fire at a high angle of elevation, and consequently the *sole* slopes upwards from the muzzle of the gun. This arrangement has the advantage of diminishing the size of the external opening or *mouth* of the embrasure, and may be advantageously used in batteries for bombarding towns, etc., where it is known from the commencement that the guns are only intended for distant fire. Countersloping embrasures are used for howitzers, which, from being very short, require in most cases more elevation than guns for corresponding ranges. The formation of embrasures in a parapet involves the removal of large quantities of earth from it, and its powers of resistance are consequently considerably weakened. It therefore is desirable not to place them as close to one another as the guns might have been placed had they been firing over the parapet. The actual space required for each gun and its detachment is 15 feet, whereas guns in direct embrasures should not be less than 18 feet apart from centre to centre; and in oblique embrasures not less than 22 feet. The block of parapet between the embrasures is called a *merlon* (Fig. 62). The term *genouillière* is applied to that portion of the parapet between the ground or platform, and the *sill* of the embrasure, or the edge formed by the intersection of the sole with the interior slope. The field carriages in the British service admit of guns being fired over a genouillière 3 feet 6 inches high, and for the garrison carriages 2 feet 3 inches is sufficient. In the Prussian service the guns can be raised on their ordinary carriages so as to fire at a height of from 5 to 6 feet, thereby obviating the necessity for an embrasure, or at all events a very shallow one will suffice. Embrasures are liable to be destroyed or damaged both by the fire from without as well as by the discharge of their own guns, which sets fire to or bursts the gabions with which they are usually reveted (Fig. 64). This latter is a serious defect, and can only be met by widening the embrasure sufficiently just beyond the neck. In siege batteries, where the guns are only required to fire in certain well-defined directions, and where, moreover, they are certain to be opposed by an accurate fire, the external opening is made only 2 feet 6 inches wide, and as it approaches the muzzle of the gun opens out in a curve. This is called the oval embrasure. It is tedious to make, but stands fire well. The revetment is secured from the effects of the flame by a covering of prepared hides. Howitzers being so short that the explosion takes place inside the battery, render it necessary to leave the neck of their embrasures unreveted at the natural slope of the soil.

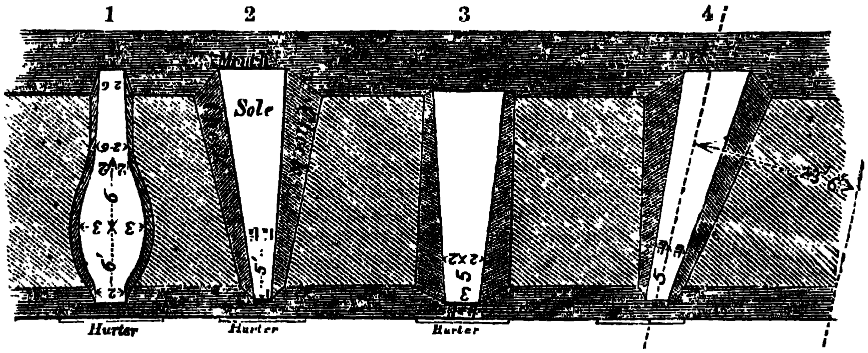

Fig. 63.—EMBRASURES—1, 2, 3, DIRECT (1, OVAL; 2, SLOPING; 3, COUNTER-SLOPING). 4. OBLIQUE.

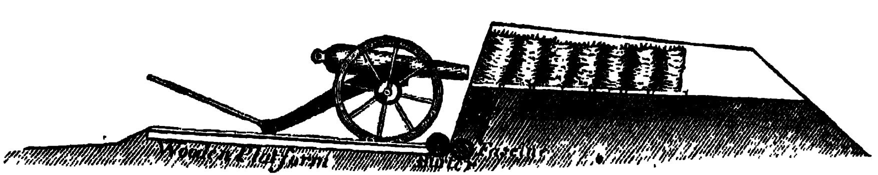

Fig. 64.—SECTION THROUGH A SLOPING GUN EMBRASURE IN A FIELD-WORK.

Barbettes are raised platforms or mounds of earth on which the guns are worked, to fire over the crest of the parapet. They are made consequently in our service 3 feet 6 inches below the level of the crest. Their size is dependent on the number of guns for which they are required, a rectangular space 15 feet broad by 20 feet long being allowed for each gun. When a gun is placed at the salient of a work, and intended to be used either to fire on the capital or at right angles to either face, care must be taken that there is room for the gun in any of the three positions. Guns are run on to the barbettes by means of ramps or inclined roadways, which are usually not less than 8 feet broad, nor at a steeper slope than 1 in 6. They should be placed on the side least exposed to fire. Barbettes have the advantage that they enable the guns to cover with their fire a large area; but on the other hand the gun detachments and guns themselves are very much exposed, and must be destroyed or silenced when an accurate musketry fire is brought to bear on them. Perhaps the greatest example in Europe of the system of defence by barbettes is in the new works at Antwerp, where almost the whole of the direct artillery defence is arranged on this principle.

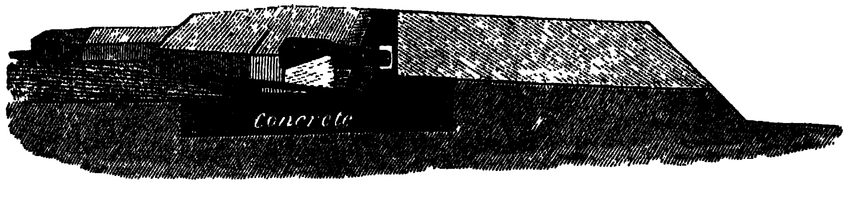

Fig. 65.—SECTION THROUGH SHIELD AND EMBRASURE OF A COAST BATTERY.

From what has been said of the relative advantages and defects of barbettes and embrasures, it will be seen that either one or the other must be adopted, according to the circumstances of the case. The salients of works seem the best positions from which to derive the full advantages of guns firing *en barbette*; whereas, in the flanks, where great lateral range is not required, and where a direct artillery attack is not to be feared, embrasures would appear to be most advantageous. The gunners working on a barbette may be, to a certain extent, protected from fire by increasing the height of the parapet right and left of the gun. An auxiliary parapet or traverse of this kind is called a *bonnette*. The men working guns in embrasures may be protected from musketry fire and splinters of shells by *mantlets*, which may either be a sort of shutter of wood plated with sheet iron, which is suspended or pivoted on a bar running across the top of the embrasure; or may be made of two or three thicknesses of rope sewn together, to form a sort of curtain or flap, which is only raised when the gun is ready to fire. Mantlets of this kind were used by the Russians in the defence of the works at Sebastopol; but there the gun fired through a small port in the mantlet itself, which did not move.

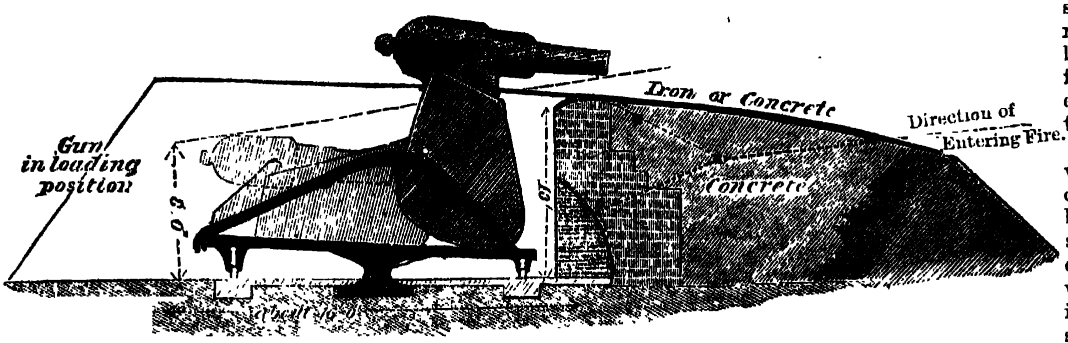

Fig. 66.—SECTION SHOWING THE AMOUNT OF PROTECTION AFFORDED BY THE PARAPET TO GUNS MOUNTED ON MONCRIEFF CARRIAGES.

In coast batteries, an ordinary type of which is given in Fig. 65, the works are of a permanent nature, and are armed with the heaviest artillery. They have to cope with a sudden and perhaps concentrated fire from ships moving rapidly past them, and firing as heavy and probably more shots per minute than the battery. Under these circumstances the only advantages possessed by the battery are, that its guns are firing from a steady platform, and that, if properly constructed, it does not suffer so much damage when hit as it inflicts on the vessels. What is more to be apprehended than the actual dismounting of the guns by the enemy's fire (which is probably not very accurate) is, that some of their shells will burst in the battery, and either effect the explosion of the magazines, the doors or windows of which must at such times be open to supply ammunition; or cause to explode by concussion or some other way the numbers of large shells full of powder, which are placed close to each gun for use. Every endeavour therefore must be made to ensure a rapid and secure means of supplying powder, shells, etc., to the guns, while the guns themselves must be isolated from one another, lest an explosion or catastrophe happening to one of them should be fatal to the rest of the battery. To effect these objects:—

1. The guns are placed much further apart, and the merlons are consequently considerably thicker than in field-works.

2. The merlons are continued inwards (Fig. 62), so as to form a traverse between each gun. Every third merlon (*i.e.*, for each pair of guns) is made longer than the others, and contains a bomb-proof magazine and room for filling shells. The shells are delivered at the guns or near them through windows in these rooms; the charges of powder being served out in a separate room, and brought up from the end of the traverse.

3. The weak part of the embrasure is strengthened by a wrought-iron wall or shield, as high as the parapet, and of sufficient thickness to withstand direct fire. This shield is supported right and left of the gun by two large wrought-iron A-shaped brackets, and the gun fires through a porthole only just large enough to admit the muzzle and allow of aim being taken. The sides of the merlon inside the battery are reveted with masonry, and arrangements are made by which a temporary roof of iron girders, rails, earth, etc., can be constructed when an attack is expected. This roof is not absolutely necessary, but would doubtless afford protection from the splinters of shells, which burst high and over the front of the battery. Of course it must not be supposed that these details are to be found in exactly the order here described in many batteries, as the important items of expense and available space will generally be found to modify some of them.

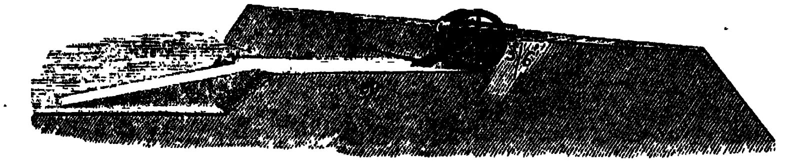

Fig. 67.—SECTION THROUGH AN ORDINARY BARBETTE OF A FIELD-WORK.

The general idea of the mode of placing guns on Moncrieff carriages behind parapets is shown in Fig. 66, and there is no doubt that it is admirably adapted to the circumstances of coast batteries, which have just been sketched out. It enables the gun to fire *en barbette*, and therefore, if mounted on a circular racer, it may follow a ship through any required arc, as is done in the case of guns mounted in a turret or cupola. As the gun is only visible above the parapet for a few seconds, it is not likely to be dismounted during that time by the necessarily somewhat random shooting of guns on such an unsteady platform as a ship's deck. The parapet behind which it works need not be of any great height above the ground level, or afford a large target for the enemy to fire at. It therefore is a most useful and admirable invention, peculiarly applicable under certain circumstances; but it is not, however, so applicable, simple, and inexpensive, or so absolutely safe from fire as might at first sight be imagined. The carriage is of wrought iron, and necessarily strong and very heavy; this involves the necessity for a firm, well-built, permanent foundation. To protect the gun when in the loading position the height of the covering parapet above the platform or racer must be 10 or 11 feet, with a reveted interior slope; and this is only of use so long as the weak part of the parapet near the crest is not blown away, an event that would easily be accomplished by one or two large shells striking the superior slope, about 8 or 10 feet from the crest. It becomes necessary, therefore, to greatly strengthen this part by masonry, concrete, or iron, the latter being the only really reliable material, but enormously expensive. If the level of the crest is really made close to the ground line, and the gun works in what sounds so simple, a mere gun-pit, elaborate arrangements must be made for drainage of it, and for the magazines and shell rooms it requires, the floors of which would be far below the ground level. There can be no doubt that where the defence must depend on the action of a few powerful guns, they can best be rendered most formidable by being placed in a revolving iron turret, which is shot-proof, and consequently only liable to damage by some accident which prevents the turret from turning. These, however, are so expensive that they can only be employed in the most important cases, and in others, where the same results are wanted, but the money is not forthcoming, the Moncrieff system will undoubtedly often be a valuable substitute. The foregoing remarks apply only to the Moncrieff system as employed in coast and permanent batteries; for as no details of his scheme for field carriages have as yet been adopted in our service, the arrangements of the works to suit them are undeveloped.

NOTABLE INVENTIONS AND INVENTORS.

XXVI.—CHARLES BABBAGE, F.R.S. (*continued*).

BY JOHN TIMBS.

At length, in November, 1842, Mr. Babbage received a letter from the Chancellor of the Exchequer, stating that Sir Robert Peel and himself had jointly and very reluctantly come to the conclusion that it was the duty of the Government, on the ground of expense, to abandon the further construction of the difference engine. The same letter likewise contained a proposal to Mr. Babbage, on the part of the Government, that he should accept the whole of the drawings, together with the part of the engine already completed, as well as the materials in a state of preparation. This proposition he firmly declined. (Abridged from "Taylor's Scientific Memoirs," Vol. III., Part 12, the facts *from authority*.) The Government, however, abandoned the completion of the work. The late Lord Rosse, on leaving the chair of the Royal Society, entered a just protest, in the name of the leading *savants* of England, against the injudicious parsimony displayed by the Government in this matter. In June, 1843, the portion of the difference engine, as it existed, was placed in the Museum of King's College, Somerset House, His Royal Highness Prince Albert being present. "The portion of the engine was in order, and was capable of calculating to five figures, and two orders of differences, at the rate of twelve or fourteen arguments and corresponding tabular numbers per minute; and neither the number of orders of differences, nor the number of digits, would make any difference in its rate of work. Without numerous carefully lettered and figured mechanical drawings, it would be impossible to describe the elaborate mechanism of this engine; it has, indeed, been found impossible for one competent mechanic, who has fully mastered every portion, to explain the machine itself to another equally competent mechanic without the devotion of a considerable time." Such was the outline of the engine with which we were favoured by Mr. William Gravatt, F.R.S., in 1860, for our "Stories of Inventions and Discoveries," with an engraving of a small portion of the difference engine drawn by B. H. Babbage; the illustration being kindly afforded by Mr. Babbage, the inventor.

The following details are from the *Times*, Nov. 4, 1871:—"Mr. Babbage's achievements here were twofold; he constructed what he called a difference engine, and he planned and demonstrated the practicability of an analytical engine also. It is difficult, perhaps, to make the nature of such abstruse inventions at all clear to the popular and untechnical reader, since Dr. Lardner,* no unskilful hand at mechanical description, filled no less than twenty-five pages of the *Edinburgh Review* with but a partial account of its action, confessing that there were many features which it was hopeless to describe effectively without the aid of a mass of diagrams. All that can here be said of the machine is that the process of addition automatically performed is at the root of it. In nearly all tables of numbers there will be a law of order in the differences between each number and the next. For instance, in a column of square numbers—say, 9, 16, 25, 36, 49, 64, 81, etc.—the successive differences will be 7, 9, 11, 13, 15, 17, etc. These are differences of the first order. If, then, the process of differencing be repeated with those, we arrive at a remarkably simple series of numbers—to wit, 2, 2, 2, 2, etc. And into some such simple series most tables resolve themselves when they are analysed into orders of differences; an element—an atom, so to speak—is arrived at, from which by constant addition the numbers in the table may be formed. It was the function of Mr. Babbage's machine to perform this addition of differences by combinations of wheels acting upon each other in an order determined by a preliminary adjustment. This working by differences gave it the name of the difference engine."

It is worth while to recapitulate the progress of the engine. The Treasury, in 1823, granted Mr. Babbage £1,500 to make the machine, which was, from time to time, voted in payment for material and labour. Five years passed, and the Government grew anxious. Another committee of scientific men was appointed. Their verdict was, in effect, "Go on—give more money; the thing must answer." More money was advanced. In 1829 the Government had given £3,000, while £1,000 had been privately spent by Mr. Babbage on the machine. It was estimated that £1,000 more would complete the work; and of this sum, all but a few hundreds, was voted. In another year, another committee was appointed. Their report again expressed admiration, satisfaction, and reliance upon ultimate success, and advised the erection of a workshop close to Mr. Babbage's house, that the work might be hastened by his constant supervision. For this and the completion of the machine, from £8,000 to £12,000 was required; and this was to be in yearly sums of about a fourth of the amount. The building was erected, the work was recommenced in 1831 (when the total expenditure rose to £17,000), and came to a stoppage. This suspension was not fully explained at the time it took place; but the mystery in which it was shrouded has been thus explained in the "Dictionary of Universal Biography:"—"In spite of the favourable report of a commission appointed to inquire into the matter, the Government were led by two circumstances to hesitate about proceeding further. Firstly, Mr. Clements, the engineer or machinist employed as his *collaborateur*, suddenly withdrew all his skilled workmen from the work, and, what was worse, removed all the valuable tools which had been employed upon it." This act is justified as strictly legal by Mr. Weld, in his "History of the Royal Society," though the tools themselves had been made at the joint expense of Mr. Babbage and the Treasury. "Secondly," says the aforesaid authority, "the idea of the analytical engine one that absorbed and contained as a small part of itself the difference engine—arose before

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* Dr. Lardner, in a lecture delivered at the Royal Institution, May 2, 1834, gave the following outline of the engine.—"The front elevation will present seven upright columns, each consisting of eighteen cages of wheelwork, the mechanism in each cage being identically the same, and consisting of two parts, one capable of transmitting addition from the left to the right, and the other capable of transmitting the process of carrying upwards; for it appears that all calculations are, by this machinery, reduced to the process of addition. There will, therefore, be 136 repetitions of the same train of wheelwork, each acting upon the other, and the process of addition with the pen that would be going on successively from figure to figure, will here be performed simultaneously, and, as the mechanism cannot err, with unfailing accuracy. The results of this calculating mechanism are transferred by proper mechanical means to the printing machinery, their types are moved by wheelwork, and brought successively into proper position to leave their impressions on a plate of copper; which copper serves as a mould from which stereotyped plates, without limit, may be taken."

Mr. Babbage." Of course he could not help the fact that, in such matters, when one great victory was achieved, another and still greater battle remained to be faced and fought. But no sooner did Mr. Babbage, like an honest man, communicate the fact to the Government than the then Ministers, with Sir Robert Peel and Mr. H. Goulburn at the head of the Treasury, took alarm, and, scared at the prospect of untold expenses before them, resolved to abandon the enterprise. Mr. Babbage, apart from all help of any kind whatever from the public purse, had spent upon his machine, as a pet hobby, no small part of his private fortune—a sum which has been variously estimated between £6,000 and £17,000. (*Times.*)

A contemporary, in a glance at the merits of Mr. Babbage's great invention, remarks: "The science of numbers, to which he devoted his days, could never, from the very nature of the case, be made popular. Arithmetical calculations must necessarily be uninteresting to the multitude, but when people were told that a machine had been invented for working out these calculations by means of wheels, or watchwork, the idea was at once comprehensible and marvellous. In reality, 'Babbage's machine' scarcely admits of simple and popular description, but the mere fact that inanimate metal could be made to perform the subtle work of man's brain came home to the public mind as a thing to be remembered for ever. There was truth, too, in the story. Though Mr. Babbage's instrument was repudiated by the Treasury, the idea of such a machine in a more manageable form has since been turned to account, and utilised in Government offices."

From reading the account of the difference engine in the *Edinburgh Review*, Mr. George Scheutz, then editor of a technological journal in Stockholm, was so fascinated with the subject, that he set about constructing a machine for the same purpose as that of Mr. Babbage—namely, that of calculating and simultaneously printing numerical tables; but, after satisfying himself of the practicability of the scheme, and constructing models, he relinquished the design. Next, his son, Mr. Edward Scheutz, being provided with a work-room in his father's house, as well as a lathe, and other tools, constructed a working model in metal. The father now applied to the Swedish Government for aid, but was refused. The father and the son then worked together, until, becoming exhausted by sacrifices for the purchase of materials and tools, yet convinced that with better workmanship a more perfect instrument was within their reach, they again applied for assistance to the Diet of Sweden. The conditions, however, on which the Diet consented to advance about £280 were so stringent that the Messrs. Scheutz renounced the work, and the model remained shut up in its case during seven years. They then obtained a pittance from the Diet, and after working day and night, completed the machine, when the Swedish Government rewarded the inventors with £280. The new engine performed its work perfectly, and in 1854 the inventors brought their machine to London, where Mr. Gravatt explained it to the Royal Society, and next to the Great Exhibition in Paris, where a jury unanimously awarded to it a gold medal. "The Emperor Napoleon," says Mr. Babbage, "true to the inspirations of his own genius, and to the policy of his dynasty, caused the Swedish engine to be deposited in the Imperial Observatory at Paris, and to be placed at the disposal of the Board of Longitude." In 1856, Mr. E. Scheutz brought the machine from Paris to London, where it was set to work in an apartment of Mr. Gravatt's house, in Westminster. In 1856, Mr. Babbage, in some observations which he addressed to the Royal Society, explained that the adding part was entirely different from his own, as well as the mechanism for carrying the tens; and that the printing part was altogether unlike. The contrivance by which the computed results are conveyed to the printing apparatus is the same in both engines, being that known as "the snail" in the striking part of the common eight-day clock. One of Scheutz' difference engines, made by Messrs. Donkin for the English Government, is (we believe) now worked in the Registrar-General's Office in Somerset House.

Of the analytical machine, the properly qualified mathematician will find and appreciate a paper by General Monabrea, of Turin, translated by the accomplished Lady Lovelace, daughter of Lord Byron: "the profound, luminous, and elegant notes forming the larger and by far the most instructive part of the work, and signed A. A. L., are all by that lamented lady." (*Gravatt.*) "We have heard Mr. Babbage say that he could construct a machine on the principles of his analytical engine, which should play and win a game of chess."—*Athenæum.*

Many years ago, Mr. Babbage printed and circulated suggestions for "Constants of Nature and Art," to form a great collection of facts which can be expressed by numbers, in the various sciences and arts. In 1855 he proposed a method of laying the guns of a battery without exposing the men to the fire of the enemy; and in the same year he suggested the application of occulting lights to military operations conducted in the night.

Mr. Babbage expired on the 20th of October, 1871, being nearly eighty years of age. He was one of the oldest members of the Royal Society at the time of his death. He was one of the only survivors of the founders of the Astronomical Society of London; and the only survivor of the founders of the Statistical Society of London, the meetings of which he attended to the last. Throughout his long life, he bore his defeats and disappointments from all quarters with true philosophy, save in some cases of vulgar annoyance. But he was, as our own experience proved, a man of generous nature, loving to indulge in kindly offices, and widely esteemed for qualities beyond his brilliant scientific renown.

CIVIL ENGINEERING.—XV.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

BREAKWATERS (*continued*).

The material of which the breakwater at Portland is constructed is, as might be supposed, mainly derived from the adjacent quarries on the island. The stone is oolite, abounding in fossils, and admirably adapted for the purpose. The mode of working the stone in the quarries is peculiar to the place. The stone lies in beds nearly parallel with the surface of the land. The beds vary in thickness from 2 to 4 feet and upwards, and are covered with a stratum termed, locally, a "cap." The capping is formed of shells in a fossil state, the ammonites being of great size; it is very hard, and is usually detached by blasting. After the cap is removed the quarrymen proceed to cross-cut the large flats which are laid bare with wedges, and split it off in masses. The blocks so split off are by no means even in surface, and the men reduce it to something of a regular shape with a tool called a "kevel," which is at one end a hammer and at the other an axe, having a short and narrow edge like a pick. The face of the hammer is not quite flat, but slightly hollowed out, by which means a rather sharper edge is secured; and it is surprising with what facility the stone is worked with this tool, and what large masses, called "spawls" or "shivers," are brought off at each stroke. The stone employed in the construction of the breakwater was wholly wrought by convict labour obtained from the prison situated on the island. It was brought down to the work by a series of three inclined planes furnished with rails, and worked in the usual manner by ropes passing over drums, having powerful breaks fixed to them. The loaded wagons in their descent draw up the empty ones. This very usual method of conveying heavy material from a higher to a lower level is by far the most economical plan that can be adopted. It is, of course, only applicable in those localities where the work to be carried out lies at the bottom of the incline, and the source of supply at the top. The actual dead weight of any load upon an incline, setting aside friction, may be represented by the fraction $\frac{n \,.\, 2240}{\text{rate of gradient}}$, the quotient being in pounds per ton. Thus, if a loaded truck weigh 8 tons, its dead weight, friction excluded, upon an incline of 1 in 20 will be $\frac{2240 \times 8}{20}$ lb. $=$ 896 lb. Again, suppose the empty truck upon a similar incline to weigh 1 ton; then *its* dead weight, friction excluded, will be $\frac{2240 \times 1}{20}$ lb. $= 112$ lb. Now, if we consider the friction due to the trucks and the rollers over which the rope passes, as equivalent to 20 per cent. of the load, we obtain as the effective dead weight of the descending load $896 - 112 + \frac{112 + 896}{5} = 583$ lb., which represents the entire force to be overcome by break power in lowering a load of 8 tons down such an incline.

Of course, many inclined planes are greatly steeper than 1 in 20, in which case the power to be overcome will be proportionately increased, because the divisor becomes smaller and the friction less. Still it is obvious that where gravity is the motive force employed, and the mechanical arrangement of the break is good, it becomes an exceedingly efficient and inexpensive method of conveying the material to the work.

At Portland, as soon as the loaded trucks arrive at the level of the work, they are transported by locomotive engines running upon rails, supported by timber stages resting upon piles driven 30 feet apart, and standing 18 feet above high water. The piles are in two pieces, made of timber 15 inches square, scarfed and bolted together. The bottoms terminate in a cast-iron shoe fitted with a Mitchell's patent screw. The entire piles are from 60 feet to 90 feet long, and are forced from 4 to 5 feet into the ground by powerful capstans. The spread of the screw prevents any great settlement into the soil, notwithstanding the weight of the engines and the loaded wagons continually passing over them. One form of screw-pile is shown in Fig. 36. The *spread* from A to B varies with the requirements of the case from 1 to 4 feet. We shall have another occasion to refer to the use of these important instruments.

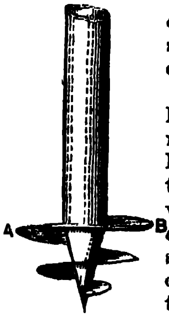

Fig. 36.

By means of five lines of rails—the number laid down on the Portland Breakwater—as much as 2,200 tons of materials can be delivered daily. The "tipping" or discharge of the rubble is accomplished by means of a wooden cam or stud fixed to the rails at the desired point. A lever attached to the under side of the wagon strikes this in passing, and detaches the key which retains the bottom of the wagon in its place; this turns upon a pivot, and the momentum acquired by the wagon causes it to "cant" when suddenly arrested in its progress, and thus empties itself of its load. The inside end is the heavier; as soon, therefore, as the load is discharged, the pivoted portion recovers its horizontal position. As the work progresses the cam is moved further on. The wagons are of wrought iron, and can load seven tons of stone. The weight of the stone in the solid block averages 16 feet cube to the ton, and when deposited in the base of the work as *pierre perdue* occupies from 20 to 21 feet cube of space.

The slope on the sea front is 5·5 to 1. The pier-heads are circular, 100 feet in diameter, cased with vertical walls of solid masonry 22 feet thick at base, and 12 feet thick at top. The interior space is filled in solidly with rubble, and grouted. The heads are built upon a foundation of rubble brought up to within 24 feet of low water, surmounted by a coursing of Yorkshire stone 12 inches thick, which covers the entire horizontal face of the rubble. The vertical walls have an exterior casing of granite laid in courses 5 feet wide and 3 feet thick, backed with Portland stone, the whole being bonded and dowelled together, vertically and horizontally. The blocks are set by means of travelling cranes working upon the upper stages, and regulated in their position beneath the water by divers.

The advantages arising from the open space which has been left in this long line of breakwater are very apparent; for, whilst the pressure of water resulting from a difference of level upon one side or the other, according as to whether the tide is ebbing or flowing, is effectually reduced by the water-way thus afforded, any waves which may enter produce only a very slight and immaterial effect upon the enlarged space of the roadstead within.

A few particulars respecting the harbour at Ramsgate, which is formed by enclosing a space of exposed water by piers or breakwaters, may not be uninteresting. The dangerous character of the coast in this vicinity, and the large amount of shipping which frequents this part of the Channel, rendered the construction of a harbour of refuge at this point a matter of absolute necessity. Even in the reign of Edward VI. an attempt was made to construct a harbour between Sandwich and Sandown Castle. This harbour consisted of a canal, traces of which yet remain. In 1574 Elizabeth appointed a commission to inquire into the subject, and in 1706 a plan was made for a harbour between Sandwich and the Downs. The proposal for a canal at Sandwich was revived in 1737, the former one having become useless. Smeaton always advocated Ramsgate as the most suitable locality for a harbour, the long stretch of coast between Newhaven and the North Foreland affording no natural break which could be turned to practical account as such. If, therefore, a harbour were to be formed between these points, it could only be by the projection of piers or breakwaters into the Channel to a distance sufficient to ensure a suitable depth of water at the entrance at certain periods of tide.

For many years previous to the period when Smeaton's advice was sought in 1774, a small haven had existed at Ramsgate, suitable, however, only for fishing-boats; and indeed so early as 1750 an extension of this harbour had been commenced by the projection of two curved arms or breakwaters, but the great and persistent silting up of the entrance by sand rendered it of little practical value. These extensions continued to advance for twenty years, and consisted of a wooden pier upon the west side and a stone pier upon the east side, each having been designed and carried out by separate engineers, or rather amateurs. After a course nearly due south, these piers gradually bend towards each other, until a contracted entrance is formed having a bearing slightly to the west of south, with an overlap upon the east side. The serious difficulty arising from the accumulation of sand within the harbour was overcome by the genius of Smeaton, who found that the sand entered with every tide, and became deposited in the still water within the piers. He therefore constructed an artificial back-water—there being no land-water available—which could be retained by sluices until the favourable period for releasing it had arrived; this had the effect of scouring the outer basin and freeing it in an effectual manner from deposit. Indeed, so powerful was the action of the scour upon the bottom, that the foundation of the piers became endangered by the removal of the chalk upon which they were built. To obviate this danger Smeaton constructed a stone apron of four courses around the east pier head and wherever protection was required, the basement course being 18 feet wide, the second 16 feet, the third 14 feet, and the upper course 12 feet, and extending vertically to within 7 feet of low-water spring tides. The depth of water at which these courses were to be laid proved an obstacle, and to facilitate the work Smeaton introduced for the first time the diving-bell, that most important adjunct to marine engineering operations, which has since then become of such constant use. The bell employed by Smeaton at Ramsgate Harbour consisted of a rectangular chest of iron weighing 50 cwt., and of sufficient weight to sink itself. It was 4 feet 6 inches high, 4 feet 6 inches long, and 3 feet wide, being large enough for two men to work in. It was supplied with a constant influx of fresh air by means of an air-pump placed in a boat near at hand. It is of interest to record the very day when the first and successful trial of this machine was made—July 7th, 1788.

The harbour as now completed contains an area of forty-two acres, the piers extending 1,310 feet into the sea. The entrance has a width of 200 feet, and possesses a depth of water at the pier-heads of 19 feet at high-water of spring-tides, and 16 feet at neaps.

The *position* of a breakwater is a point requiring very great forethought and investigation on the part of the engineer. It is at all times an expensive structure, and it therefore becomes desirable to place it where the greatest possible benefit shall be derived from it. Every stone must, in fact, be utilised to the utmost. The general character of its construction may be gathered from the foregoing remarks, and it may be assumed that that system which has proved efficient and durable in more exposed situations, will be equally durable in other localities. Nothing appears to form so substantial and so economical a base for a breakwater as large rough blocks of stone thrown down from the surface along the intended line of the breakwater. The slope will thus assume a natural angle, which the wash of the waves will eventually consolidate in character. It must, however, be borne in mind that in any calculation of *quantity* required for a base, the *natural* talus will vary with the size of the component parts. Thus we find that a *sandy* shore assumes by the natural action of the sea a position nearly *horizontal*; a pebbly beach presents a greater slope to the water; large boulders a still steeper front; and the solid rock stands with an almost vertical face exposed to the waves.

The set of the tides, the velocity and direction of currents, the prevailing winds, any local advantages arising from projecting headlands, isolated rocks, and so forth, must be carefully considered; and, above all, the utmost facility afforded for vessels driven by stress of weather to avail themselves of the security afforded by the breakwater. The necessity for beacons, to enable vessels to make the entrance, and to avoid stranding upon that which is intended for their benefit, is a point which scarcely need be insisted upon. The character of such beacons will be considered in its proper place.

Hitherto our remarks have been confined to *fixed* breakwaters, that is, those which rest upon the solid bottom. But there is another class of breakwater to be considered, and one about which considerable difference of opinion exists; we allude to *floating* breakwaters.

Most of our readers are aware of the fact that when a small boat desires to communicate with a large ship riding at anchor in rough water, it always seeks to do so if possible upon what is termed the *lee*-side of the ship, that is, upon the side *opposite* to that on which the wind strikes, and the reason for doing this is, because there exists a very perceptible difference in the state of the water upon the two sides, the lee-side being very much smoother. Now the reason of this difference is simply due to the fact that the large vessel, although itself floating, and to a certain extent influenced by the waves, has acted as a breakwater. It is not difficult to suppose that a fact so obvious should have raised the idea of employing old hulks, or floating structures specially designed for the purpose, and moored in a continuous line across the mouth of the port or harbour requiring protection, for this specific purpose. Those who advocate the system urge its superior economy over a regularly-built structure, and the facility with which any one of its constituent parts can be removed for repairs, or replaced, and there can be no doubt that in both these respects it has its advantages. On the other hand, it is evident that inasmuch as the stability of each portion is dependent upon the mere strength and holding power of the mooring arrangements, it is possible that such a storm might occur as would render any such arrangements unable to cope with its fury, and that then, at the very period when its value as a shelter would be the greatest, it would cease to be of use, and the ships which had been driven from the storm without to seek safety within would, being land-locked, be in a far worse position than had they never sought its shelter. And again, it may be urged that, granted the cables and anchors did their duty and withstood all the force of the wind and water, yet the shelter afforded is after all only a partial shelter, for the larger waves by which the breakwater itself is influenced will inevitably pass beyond it and enter the port, producing disturbance and commotion amongst the shipping; for it may be taken as an acknowledged fact that *nothing* will break and expend the fury of an advancing wave more surely than a sloping shore; even a solid wall or rock, if its face is vertical, will permit the wave which rolls against it to recoil and pass on elsewhere, diminished slightly, it is true, in altitude, but still powerful for mischief.

With respect, therefore, to floating breakwaters, we are confined to this fact, that only a certain amount of benefit can result from their use. The larger the floating structure the better, provided the size is thrown in the right direction. Arguing from the fact that an *immovable* structure will prevent the passage of a wave, it is evident that the less easily a floating structure is influenced by the wave, the more shelter will it afford. What, then, should be the form or character of the structure? If this question can be satisfactorily settled, we may yet hope to gain some advantage from the use of floating breakwaters. Now, that peculiar characteristic of floating bodies which we term "buoyancy" is not strictly the same as its power of floating. Its use is rather to be restricted to bodies whose shape or material renders it very readily moved *vertically* by a passing wave. A cork is in this respect strictly buoyant, and it is buoyant because its *material* is buoyant. A broad thin dish of iron is also buoyant, but this is buoyant because of its *shape*; or because the surface resting upon the water is large in proportion to its absolute weight. But it will be possible to shape a vessel out of an equal mass of iron, so that although it shall float, it shall not be buoyant in the sense we speak of. By reducing the base and throwing the metal into the sides—the *thickness* remaining the same in either case—we shall obtain a vessel which will be far less readily influenced by a passing wave than the shallow dish would be. Here, then, we have the key to the form of structure best suited to stop the progress of a wave. Neither is it difficult to prove the truth of our statement. Let us assume a mass of material—iron for instance—of a given weight. Then let it be shaped into a vessel of such a shape as that its line of floatation shall be one-quarter its height. Again, let an equal weight of iron be so shaped as that its line of floatation is three-quarters its height. Now, if the iron employed be of equal thickness in either case, the difference in the height of the floating line can be obtained only by reducing the maximum horizontal section below the line of floatation, in this case to one-third, and the effect of this reduction will be to diminish the vertical effect of a passing wave upon the body, in this instance by two-thirds, because the pressure exerted by water—other things being equal—is in every direction directly proportional to the surface acted upon.

It follows from this that, in the case before us, a wave of three feet vertical height will produce no greater effect upon the deeper floating vessel than a wave of one foot vertical height will upon the shallow vessel, and consequently its altitude or effect upon the opposite side will be proportionately diminished. It would, perhaps, not be too much to assert that the greatest beneficial effect would result from a screen or wall of iron-plate standing vertically in the water, the lower end nearly touching the soil at low-water springs, and the upper end buoyed by means of casks or other appliances fixed on the *inside* of the plate, the whole being strongly secured by chains to efficient moorings. In order to present a less obstructive face to the waves such a structure might be curved slightly inwards at the upper part.

The theoretical effect of such an arrangement would be almost entirely to stop the progress of an advancing wave, because, whilst the whole mass would rise and fall by the action of the long tidal wave, the more sudden rise of an ordinary wave would be felt only upon the outer face, and would not act upon the buoyant portion on the inside.

Still, when it is remembered that the force of a wave will hurl before it a mass of solid rock of many tons weight, the almost utter hopelessness of securing against the attacks of the sea a wall of iron of an extent sufficiently great to be of practical utility as a breakwater, becomes apparent.

Upon the whole, therefore, we incline to the opinion that floating breakwaters are amongst those achievements of engineering which, although by no means impossible, and undoubtedly desirable, have yet to be accomplished.

TECHNICAL DRAWING.—LXI.

GOTHIC STONEWORK.

GLOSSARY (*concluded*).

Bracket—An ornamental projection from the face of a wall to support a statue, etc. Brackets are sometimes nearly plain, or ornamented only with mouldings, but are generally carved either into heads, foliage, angels, or animals. They are very frequently found on the walls in the inside of churches, especially at the east end of the chancel and aisles, where they supported statues which were placed near the altars.

Cathedral—The principal church where the Bishop has his seat (*cathedra*) as diocesan. It is so called in contradistinction to *abbey* or *priory* (see these), which may be churches of equal or greater size or importance, but are not presided over by a bishop. It is said no town can correctly be called a *city* unless there be a cathedral therein.

Frithstool, or **Freedstool**—Literally, "the seat of peace" (German, *fried-stuhl*, "peace-chair"). A seat or chair placed near the altar in some churches, the last and most sacred refuge for those who claimed the privilege of sanctuary within them, and for the violation of which the severest punishment was decreed. They were frequently if not always of stone.

Galilee—A species of porch where, it has been said, the female relatives of the monks went to confer with them, they not being permitted to enter the conventual buildings.

Gargoyle, or **Gurgoyle**—Carved terminations to the spouts which conveyed away the water from the gutters, and are supposed to be called so from the gurgling noise made by the water passing through them. Sometimes they are perfectly plain, but are oftener carved into figures or animals which are frequently grotesque; these are very commonly represented with open mouths, from which the water issues; but in many cases it is conveyed through a leaden spout, either above or below the stone figure.

Grille—The ironwork forming the enclosure screen to a chapel, or the protecting railing to a tomb or shrine. Grilles are more common in France than in England.

Groin—The angle formed by an intersection of vaults. Most of the vaulted ceilings of the buildings of the Middle Ages are groined, and therefore called groined vaults, or groined ceilings. During the earlier part of the Norman style the groins were left perfectly plain, but afterwards they were invariably covered with ribs.

Hammer-beam—A beam very frequently used in the principal timbers of Gothic roofs to strengthen the framing, and to diminish the lateral pressure that falls upon the walls. Each principal has two hammer-beams, which occupy the situation of a tie-beam, and in some degree serve the same purpose; but they do not extend across the whole width of the roof. The ends of hammer-beams are often ornamented with heads, shields, or foliage, and sometimes with figures.

Lantern—A turret raised above a roof or tower, and very much pierced, the better to transmit light. In modern practice this term is generally applied to any raised part in a roof or ceiling, containing vertical windows but covered in horizontally.

Lich-gate—A covered gate at the entrance of a cemetery, under the shelter of which the mourners rested with the corpse while the procession of the clergy came to meet them.

Miserere—Seats in the stalls of large churches, made to turn up and afford support to a person in a position between sitting and standing. The underside is generally carved with some ornament, and very often with strange, grotesque figures and caricatures.

Piscinæ—Hollows or niches near the altars, with drains to take away the water used in the ablutions at the Mass. They seem at first to have been mere cups or small basins, supported on perforated stems placed close to the wall, and afterwards to have been recessed therein and covered with niche-heads, which often contain shelves to serve as ambries. They were rare in England till the thirteenth century; but there is scarcely an altar of later date without one. They frequently take the form of a double niche with a shaft between the arched heads, which are often filled with tracery of an elaborate character.

Poppy-heads—The finials or other ornaments which terminate the tops of bench-heads, either to pews or stalls. They are sometimes small human figures or heads; sometimes richly-carved groups, images, knots of foliage, or finials, and sometimes fleurs-de-lys, simply cut out of the thickness of the bench-end and chamfered.

Priory—A monastic establishment, generally in connection with an abbey, and presided over by a prior, who was a subordinate to the abbot. (See Abbey.)

Refectory—The dining-hall of a convent, monastery, college, etc. The internal arrangements and fittings were very similar to those of the ordinary domestic halls, except that it was usually provided with a raised desk or pulpit, from which, on some occasions, one of the inmates of the establishment read to the others during meal-time.

Reredos—The screen or other ornamental work at the back of an altar.

Sacristy—A small chamber attached to churches, where the chalices, vestments, books, etc., were kept by the officer called the Sacristan.

Sedilia—The seats near the altar in churches, used by the priest and officiating clergy during certain portions of the mass or communion service. They are generally three in number.

Tabernacle—A species of niche or recess in which an image may be placed.

Tabernacle-work—The rich ornamental tracery forming the canopy, etc., to a tabernacle. It is common in the stalls and screens of cathedrals; and in them is generally open or pierced through.

Tympanum—The triangular space between the horizontal and sloping cornices on the front of a pediment in Classical architecture. It is often left plain, but is sometimes covered with sculpture. This name is also given to the space immediately above the opening of a doorway, etc., in mediæval architecture, when the top of the opening is square and has an arch over it. This arrangement is not uncommon in this country in Norman work, and on the Continent is to be found in each of the styles. This kind of tympanum is occasionally perfectly plain, but is generally ornamented with carving or sculpture. In Continental work the subjects are usually arranged in tiers one above another, and often embrace a great number of figures. Also when an arch is surmounted by a gable-moulding or triangular hood-mould, the space included between the arch and the triangular hood-mould is termed the tympanum of the gable.

PRACTICAL APPLICATION OF THE FINE ARTS.—IX.

THE ART OF MOSAIC.

By P. H. Delamotte, Professor of Drawing, King's College, London.

By mosaic we understand the art of putting together pieces of various materials, either white or particoloured, in such a way as to form definite patterns. Just as a musical note differs from a mere sound by the fact that there is a certain rhythmical arrangement of pulsation instead of vibration repeated at no certain interval, so does a mosaic pavement, for instance, differ from an ordinary pavement, in having the materials arranged in a certain order, according to their shape or colour. We do not wish to imply that pavement is the only purpose to which mosaic can be applied, but it gives the readiest means of explaining what we mean by mosaic, and it appears to have been the earliest purpose to which mosaic was applied. Pavement was that kind of flooring formed by the pavior by striking or beating, as the word implies, the materials into a firmer consistency than the mere stone and concrete would otherwise take. Mosaic is essentially an architectural art; whether it be applied to ornamentation of pavements, to the facing of walls, or the copying of pictures, or the decoration of furniture. The small scraps of Roman work that are inserted in jewellery are mere toys, simply imitating that which is the real art.

The origin of the art, like that of many others of far more importance to the well-being and the culture of man, is lost in obscurity, and yet we can trace it far enough to feel sure that it must have arisen amid the early civilisation of the great empires of Western Asia. The same word which Ezekiel uses to describe the pavement as seen by him in his visions of the new temple, and which no doubt he idealised from the actual pavements in Assyria, is used also of a pavement upon which Ahaz, the King of Judah, who copied, at least, Assyrian altars, placed the "sea" when he had removed it off the brazen oxen; and is also employed in the book of Chronicles to designate the floor of the court in which the Israelites assembled at the dedication of the temple in the reign of Solomon. Amid the remains of Nineveh now deposited in the British Museum, there are floors of stone or alabaster cut into patterns. After the destruction of Nineveh we find in Persia, at Shushan (Susa), that Ahasuerus, according to the book of Esther, made a feast "in the court of the garden of the king's palace," and after the description of other decorations, it continues, "Upon a pavement of red, and blue, and white, and black marble." These latter words are translated by some modern scholars to mean alabaster, white marble, mother-of-pearl, and red marble. The mother-of-pearl we should think must be a material of doubtful advantage in any surface which had to undergo the wear and tear of much traffic; perhaps in the court of the garden of a king's palace endurance might have been willingly sacrificed to beauty of appearance. The whole account reads so like some of the drinking scenes portrayed in the Ninevitish sculpture, and especially one in which a king is represented as drinking with his queen, he reclining in a couch, and she sitting laughing in a straight-backed chair in a "court of a garden," with vines trellised around, that we cannot but think that the Persians took some of their decorations from their predecessors in dominion. We know that the Greeks, who took the origin of all their arts from Asia or from Egypt, and so improved upon the stagnant and Oriental character of each that they handed them down to their successors in forms scarcely to be recognised as belonging to the original model, made use of this style of decoration in their noblest buildings. Unfortunately, none of their works remain to us, but as Greece disappeared her treasures were swept into the all-gathering net of Rome; and mosaic begins to flourish in Italy just when the old Romans advance to the study of Grecian art, and language, and philosophy. The subjugation of Greece brought many Greek artists to Italy, and some of their work remains to testify to the fact. The oldest Roman name for mosaic is *lithostrotum* (λιθοστρωτὸν), a word showing, as words so often do, by its Greek derivation, that the origin of the art as far as the Romans were concerned, was Greek. It was on such a *lithostrotum* that Pilate from his judgment-seat delivered over the rejected Jewish king to be crucified as a slave might have been.

The oldest piece of mosaic known to exist is that at Palestrina, formerly Præneste, near Rome, where it was placed in the Temple of Fortune by Sulla, B.C. 80; but the Greek workmen left the inscription on it in their native Greek character. From that day to this the art has been principally cultivated by the Italians. Wherever the Roman arms extended their sway, there their soldiers carried with them the luxuries they were accustomed to at home, hence Gaul and Britain contain many remains of this their work; and their descendants to the present day in Rome itself, in Florence, and in Venice, have excelled and do excel in different branches of this same art.

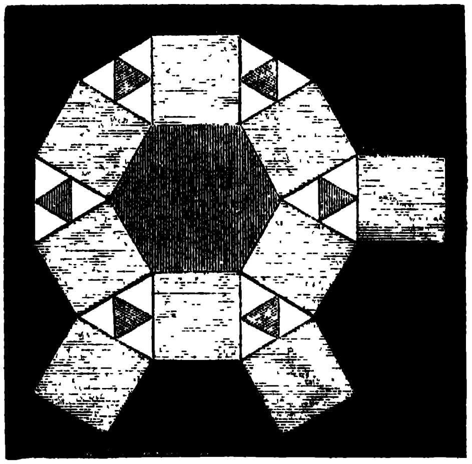
Fig. 16.—OPUS SECTILE IN CHURCH OF S. CROCE IN GERUSALEMME, AT ROME.

The name for mosaic amongst the Romans we have noticed was of Greek origin—all the names for the different varieties of mosaic, and these were numerous, were of native growth. In the first place we have the *opus tessellatum*, whence we derive our phrase of tesselated pavement. This takes its name from the *tessellæ* or *tesseræ*, the technical name for the small cubes or pieces of which the pavement is formed. In the *opus tessellatum*, the tesseræ were small cubes or square dies of about three-quarters of an inch square, sawn or worked by the hand into proper shape, and then arranged in geometrical patterns. The colours first employed are supposed to have been black and white, but at a later period other colours came into use, as they were found advantageous in other kind of mosaic, and had been employed in the species called *opus figlinum*, which will be described afterwards. The same kind of tesseræ were used also in other sorts of mosaic, but it was not called *tessellatum*, unless the component parts were exclusively of this square shape. There are many specimens of this work in various parts of this country, as for instance at Claxby, in Lincolnshire (where the colours are blue, white, and black), in many of those pavements discovered beneath the city of London, in the borders of the finer floorings and in the smaller passages of many of the Roman villas discovered in various parts of this country. The finest specimens no doubt are to be found in Italy, in the excavations of Herculaneum and Pompeii, in the Sala of Nuovo Braccio in the Vatican, and especially in the Baths of Caracalla, at Rome.

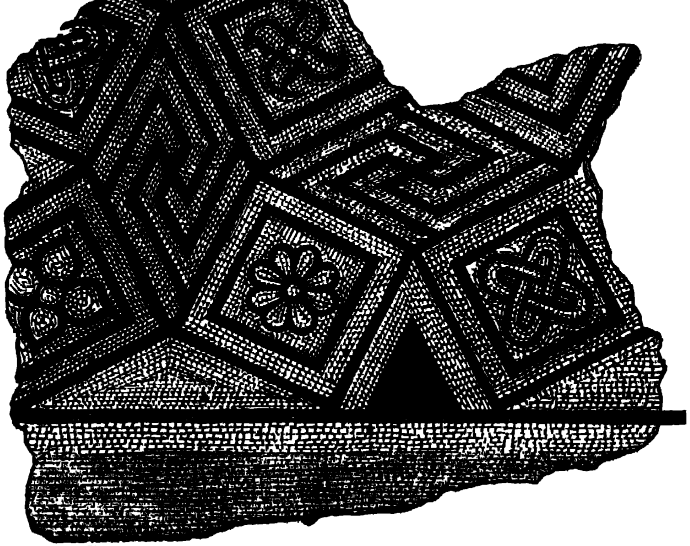
Fig. 26.—FROM THREADNEEDLE STREET, LONDON.

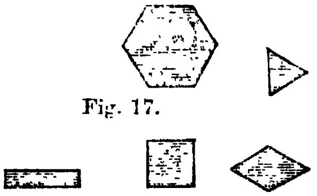
Fig. 17.

The *opus sectile* is called after the *secta*, or portions cut out from the coloured marbles or *crustæ*. In this work the marbles were divided into various shapes—triangles, squares, oblongs, rhomboids, hexagons, etc., as in Fig. 17. These are combined so as to compose regular geometrical figures of more or less intricacy, but in no case is an attempt made to imitate any natural object. The materials used are very various. In a pavement in the church of S. Croce in Gerusalemme, at Rome, a pattern is formed of hexagons of *pavonazzetto* (a purple stone), surrounded with squares of red porphyry, the intermediate equiangular triangles being composed of four smaller triangles, three of palombino, and one of serpentine, Fig. 16. This species of work is never found in this country, and it is not common in Italy. The earliest date assigned to it is B.C. 100. In the Pantheon at Rome and in St. Peter's may be seen the finest examples.

The *opus figlinum* or *figulinum* differed from the former in several particulars—in material, in pattern, and in employment. Whereas the former sorts of mosaic were composed of marbles and natural stones, in this work a species of encaustic tile or terra-cotta, sometimes called "ceramic tesseræ," was employed, hence it was called *figulinum*, from *figulus* (a potter, or maker of fictile ware). These were more or less of a vitreous composition, formed principally from alumina, but having various colours produced in them by the addition of metallic oxides. Sometimes these tesseræ were combined with natural marbles, alabaster, etc., and in those works do we find for the first time gold introduced. This was employed in somewhat of the same manner as it was in later times, and is still used in Venetian mosaics. On a thick groundwork of the vitreous compound, in shape like a thin tile sunburnt (and thus Salviati and Co. employ various deeply-coloured glasses to give a different tone to the slightly transparent gold) a piece of gold-leaf is laid; upon this again a thin coating of transparent glass is placed, and the whole transferred to a kiln and burnt much in the way in which stained glass is burnt after it is painted. The main difficulty, of course, is to know when the tile has been submitted to sufficient heat to vitrify the material without giving it sufficient liquidity to allow the gold to run into masses. The whole should become homogeneous, and the union of parts should be perfect, but it should not run. Besides being different in material, the *opus figlinum* differs also in pattern. We have now introduced imitations of natural objects, leaves, fruits, and figures. The effect of this, of course, was soon visible upon other kinds of mosaic, and we not unfrequently find mosaics—formed wholly or in great part of marble and natural stone—which portray men and animals, as well as flowers and fruit, though this rather belongs to the next kind that we shall describe; but we, too, may note that none of these designs appear earlier than the invention of the *opus figlinum* which, Pliny states, was made B.C. 24. The use, too, of this species of mosaic was different from that which we have described before. The former kinds were employed almost exclusively for pavements; but with the new material and new designs mosaic began to be used for walls, for ceilings, and even for the decoration of furniture. The Baths of Agrippa afford one of the best examples of the ancient form of this beautiful kind of work.

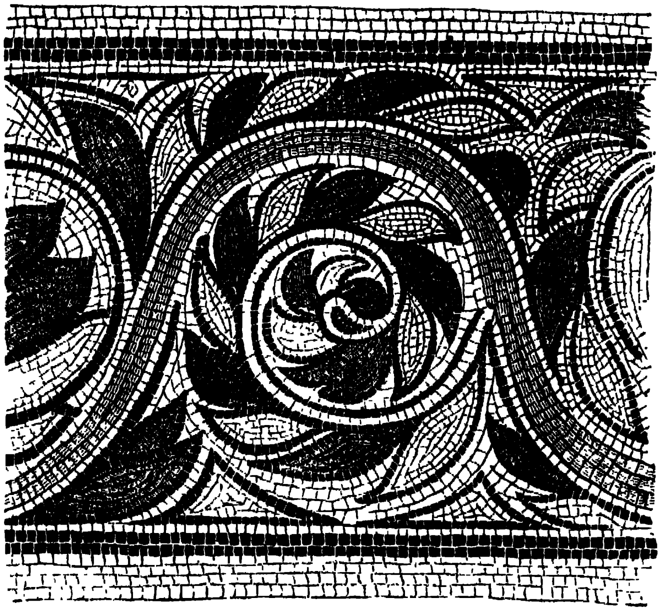

Fig. 19.—FROM WOODMANCHESTER, GLOUCESTERSHIRE.

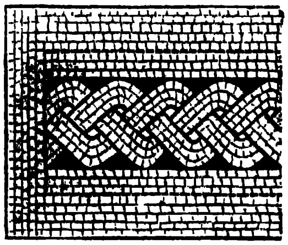

Fig. 22.—FROM CIRENCESTER.

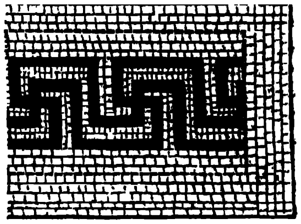

Fig. 23.—FROM CIRENCESTER.

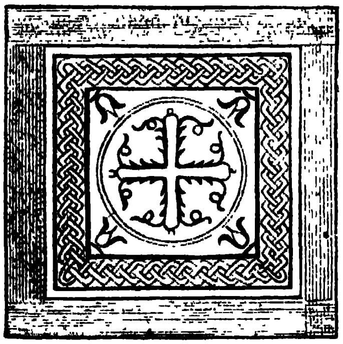

Fig. 21.—FROM BANK OF ENGLAND

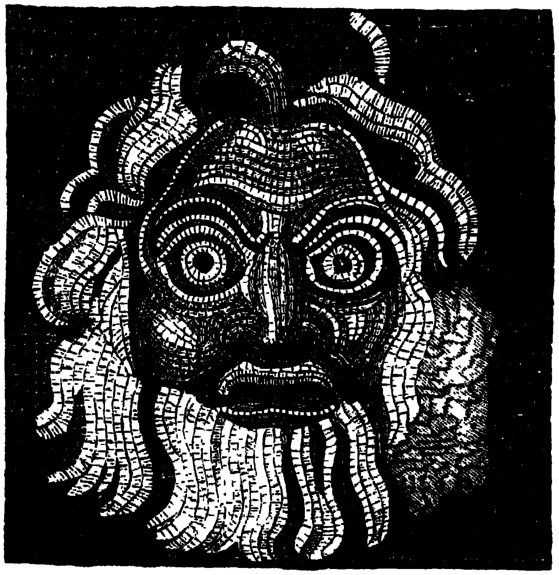

Fig. 18.—FROM BATHS OF AGRIPPA.

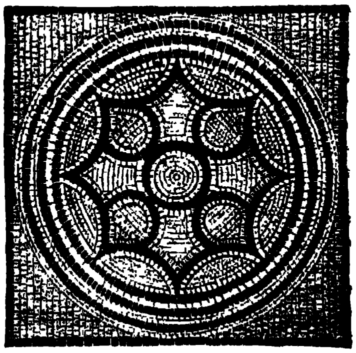

Fig. 20.—FROM ABBOTS ANN, HANTS.

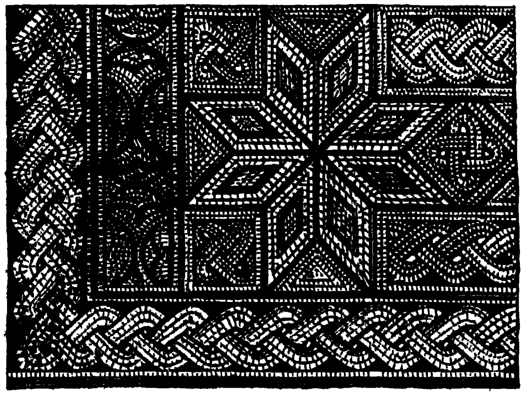

Fig. 25.—FROM CIRENCESTER.

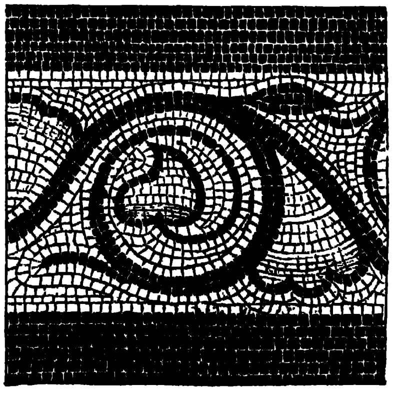

Fig. 24.—FROM CIRENCESTER.

But the most important of the ancient mosaics was the *opus vermiculatum*, which was formed of tesseræ of irregular shapes or sizes, varying from half an inch square to one-twentieth of an inch. The pieces were individually adapted to their position, so that they might follow the lines of the design, and thus in the background or in large spaces of even colouring these divisions caused an appearance like a mass of worms wriggling, hence the name *vermiculatum*, from *vermes* (a worm). In this work naturally the artist employed whatever material would give him the desired colour and shade, and though marble was probably preferred, this was supplemented by fictile work. In a quantity of mosaic work found on the site of a Roman villa at Cirencester, the materials employed were principally freestone, oolite, sandstone, limestone lias of various colours (and some of these had been altered by heat), and a little chalk; some colours, especially reds and blacks, were of terra-cotta, and in one case a bright red was produced by a ruby glass. The colouring matter in this latter case was an oxide of copper. During the long period of burial beneath the earth, the surface of the coloured glass had decomposed into verdigris and silica, leaving an appearance of a bright green; as this bright green came in masses in the midst of a duller green representing leaves, it gave an appearance of very dull colouring, until it suggested itself to Professor Buckman, to scrape off the green and the dull white beneath it, and thus to discover the bright red below. Thus we see that the Romans employed whatever material came to hand—in the *opus figlinum*, they used exclusively terra-cotta or a kind of glass; in the *vermiculatum* they brought in marbles of all colours, alabaster, commoner sorts of stone, sandstone, freestone, etc., and even chalk, and the colours not readily producible by this means they produced by means of tiles and glass.

There are three recognised classes of the *opus vermiculatum*. The *majus*, which is applied to pavements or ceilings, and is commonly of only black and white marble. In this material figures are produced which, though somewhat coarsely drawn, are very effective, and exceedingly spirited. There are good examples of this in England, but the most striking perhaps are to be found in the Baths of Caracalla, at Rome. The second kind is called *medium*, and is employed in the decoration of walls. The character of the designs is principally festoons of flowers, and figures of cupids and nymphs. Naturally, from the position of this work, it is more likely to perish as the wall decays than when placed as a pavement, when it merely gets covered over, and, dropping out of sight, is preserved by that which hides it. The wall, on the other hand, falls, breaks as it drops, and the mosaic crumbles into a mere handful of curiously-chipped pebbles. There are, however, some remains of this *medium* work in the Vatican and in the Museo Borbonico at Naples brought from the neighbourhood of Pompeii; besides minor specimens, there is the well-known representation of the contest of Alexander and Darius, at the battle of Issus. This, perhaps, is the finest example of the ancient Roman mosaic work known to exist; for though we know that no Roman of the upper classes thought his house complete without decoration of this kind, the houses themselves have so completely disappeared in the course of sixteen or seventeen centuries that but very few specimens remain to us.

The third kind of *opus vermiculatum* was called *minus*, and was employed principally as mere ornament, or as an adjunct to the ornamentation of furniture. This, of course, was far more delicate in its construction than the others. It consisted of minute particles of marble and fictile ware, sometimes not one-twentieth of an inch across, and was more like the modern Roman or Florentine work than the coarser kinds of which we have been speaking. It was of this kind it is supposed that the mosaic was composed which it is reported that C. Julius Cæsar carried about with him on his campaigns. Probably the taste that found vent in this way contributed not a little to his popularity with his contemporaries, and his fame among posterity. Pliny describes with great admiration a mosaic of this character, which represents doves drinking from a vase, which actual work or a copy thereof still exists, and the design must be well known to all who are interested in mosaic work.

The *opus scalpturatum* was somewhat different from the former, inasmuch as in all those cases the various coloured materials were embedded in a layer of plaster or cement, whilst in this the marble itself was made the foundation for a process of inlaying. The marble was hollowed out, the grooves were filled up with grey or black marble, or sometimes with composition. In the Capitol at Rome is preserved a map of the city made in this way. It originally formed the floor of the Temple of Romulus and Remus, and seems to have given the position of every house in Rome. In the cathedral at Sienna a picture is produced by inserting grey marble in a foundation of white, and in the required places deepening the shadows by crossed grooves filled with a black composition. This, of course, is much later work, but probably the Romans carried this decoration to a greater degree of perfection than any remains of their work would lead us to suppose.

There was still another species of mosaic, called *asarotum opus*, which as its name was Greek, was probably introduced from Greece. It would imply an appearance as of an unswept floor, either dotted with crumbs, or having the chips from other workers scattered about it. This probably resembled the Venetian *pisé* floor, or the common Italian *trazzo*. It was rather a trick of an artist than what could fairly be called an artistic work.

The above were the principal styles of mosaic used by the Romans during the time that they remained heathen; the later work though not necessarily connected with Christianity or arising therefrom, is so much influenced by Christian art that we cannot but make a pause between the old and the new. The *vermiculatum*, indeed, did last on into Christian times, of which we have an instance in this country (and it is believed to be the earliest instance) at Horkstow, in Lincolnshire; but in this case pagan deities are mixed up with Christian monogram in a most extraordinary manner, and it almost looks as if the monogram had been introduced by some Christian workman in a surreptitious manner. In the first kind of mosaic which we are about to mention as having arisen after Christianity was somewhat extended—in Italy at least—there was not much more than these monograms to denote the intention of the workers, still it seems to have had its effect upon the work, which henceforth was devoted more especially to churches, and was certainly less used in private dwellings, if not also in public buildings of a secular character. But in the second the religious influence was far more marked. It gave a tone to the whole, and if the mosaics of the fifth, sixth, and following centuries not only surpass all previous work of the same character, but possess a grandeur of their own which we seem quite unable to rival at the present day, it is certainly owing to the deeply-imbued faith and the strength of religious feeling in those early Christians who did not halt between two opinions as to religious art, but strove to teach their people with the teaching of the eye with as much earnestness as they essayed to impress its doctrines by their oral discourses. If, as Mr. Ruskin says, religion has not gained by its alliance with art, it is impossible for any one to look upon the mosaics of San Marco at Venice, or the grand series at Ravenna, in the church of San Apollinare Nuovo, in the Archbishop's private chapel, in the Baptistry of St. John, in the Basilica of San Vitale, the Mausoleum of the Empress Galla Placidia, and, though last not least, the Basilica of San Apollinare in Elasse, outside the town, without feeling that art owes much to the strong religious feeling which prompted the conception and carried through the construction of such heart-stirring and magnificent work.

To return to our description of the various styles of mosaic. The first which came into existence after the spread of Christianity are called the *opus Alexandrinum*, to which we find such constant allusion, and of which so many remains of ancient work is still to be found, especially scattered about through all parts of Italy. This style of work originated in the fact of the Emperor Alexander Severus, who reigned between the years 222 and 235 A.D., having procured a quantity of porphyry and serpentine on his return from Alexandria, and this was inserted in channels chased out in slabs of white marble, in a manner not very unlike the *opus scalpturatum*, which we described before, excepting that this earlier work seems to have consisted principally of white and black and grey, and did not show forth the strong colours of porphyry and serpentine. The production of this work lasted on until the beginning of the fourteenth century. The finest specimens, it is said, are to be seen at the Certosa at Pavia; and in this country Westminster Abbey and Canterbury Cathedral furnish examples, both the work of Italian artists.

The next improvement was a return to something like the old *opus vermiculatum*. It consists almost entirely of sacred subjects, in which but slight shadows were used, just as we see in the pictures of the same period, and the whole stands forth from a ground of gold, recalling the sacred pictures in use in the Greek Church. No doubt there was a strong Oriental or Byzantine influence at work upon this art, for the finest specimens are to be found in Venice, the port by which mediæval Europe held its intercourse with the East; in Ravenna, so long the capital of the exarchate dependent upon the Eastern Empire; and in Sicily, which always had an Oriental tinge—

> "Because Greeks are Greeks, and hearts are hearts,
> And poetry is power."

So that we find in this Greek art, flourishing on a soil imbued with much good blood of Greeks, and compelled to teach a religion sprung from Syria but nourished in Greece, much of Oriental repose and grandeur, much of deep and dignified expression, portrayed in fixed and stereotyped forms.

Sir Digby Wyatt gives it as his opinion that the earliest work, such as that at Monreale near Palermo, was produced by first covering the whole ground with gold-surfaced tesseræ strongly bedded in plaster, and that afterwards the patterns to be inserted were picked out and filled up with the various colours required. This, at all events, does not seem to have been the plan on which the mosaicists of Venice and Ravenna worked, for we find their work is gradually fitted round to the outlines of the figures, and by their lines directing the eye to the main purpose of the picture.

There remains but to mention the geometrical glass mosaic, which is usually inserted in grooves of white marble, and made to subserve to the decoration of friezes and columns, and in fine forms of reredos and pulpits. Regular geometrical figures, especially equilateral triangles and hexagons, are the common forms employed, but these are not formed of regular-shaped pieces of glass, but of bits broken off, and in some cases ground down. The pieces from which these fragments were chopped off were originally about six inches square, and half an inch thick. These pieces were fitted to their places, and fastened down with a cement formed of lime and a little powdered stone. This character of mosaic was common until about the middle of the fifteenth century, when fresco-painting obtained such a mastery over other modes of external and mural decoration that the mosaic, with its Oriental tendency to retain traditional forms, was unable, especially after the taking of Constantinople cut off almost all intercourse with the Eastern Empire, to hold its place in the public estimation. There always has been, however, a certain amount of mosaic made in Rome, in Florence, and in Venice.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXIII.—JOHN DALTON, D.C.L.

BY JAMES GRANT.

Among those men whose lives form eras in the history of science we may justly number John Dalton, the second Newton of English physics, the author and expounder of the "Atomic Theory," who was born on the 5th of September, 1766, at Eaglesfield, a township in the parish of Brigham, in Cumberland. His father, Joseph Dalton, by the death of an elder brother, became proprietor of a small copyhold estate, which he thriftily farmed with the aid of his sons. He gave his family the best education his slender circumstances would permit, and his second son, John, was educated at a school conducted by a member of the Society of Friends till he attained his twelfth year.

Young Dalton must have made remarkable progress there, and developed early talent, as in his *thirteenth year* he commenced a school in his native village, and continued to teach there until the winter of 1781. All the time he could spare from this vocation was devoted to assisting his father as a farm labourer. At this period he began the study of mathematics, in which he was assisted by a kind and accomplished lady named Robinson. An anecdote is told of the boy teacher which exhibits the early possession of that confidence which formed a leading feature of his future character:—"The correctness of one of his solutions being questioned, he persisted in its accuracy, backing his opinion with a bet, the result of which was a supply of candles through the winter for his little school."

On attaining his fifteenth year he was appointed usher in the school kept by his cousin, George Bewley, at Kendal, where, until 1792, he was entirely employed in acquiring and teaching the physical sciences and mathematics. Prior to this, in 1788, he commenced those meteorological observations which led directly or indirectly to all his great discoveries, and which he continued without intermission until the day before his death. While residing at Kendal he gained the friendship of a blind gentleman, named Gough, who had an excellent library and some chemical apparatus, all of which he placed fully at the disposal of Dalton, who became his assistant and companion, and who in return was never weary of expressing the obligations he owed to him; and to these he referred when, in 1793, he published his first work, entitled, "Meteorological Observations and Essays." His observations on the weight of the atmosphere led him to the discovery of the fact "that the rise and fall of the barometer depend upon the amount of watery vapour floating in the air; every grain of water when dissolved in that medium becoming an elastic vapour capable of sustaining $\frac{1}{24}$th of an inch of mercury. He connected the Aurora Borealis with magnetic phenomena, and explained the cause of the trade winds without being aware of the explanations of others on these points." From 1794 to 1803 he was busy with experiments on such subjects as the force of steam, evaporation and the expansion of gases by heat, the deposition of dew, the fall of rain, the secret origin of springs, the power of fluids to conduct heat, the constitution of mixed gases, all the while conducting his meteorological observations with singular regularity and minuteness. For more than fifty years of his life he was in the habit of making a dozen of those observations daily; and it would indeed have been remarkable if from such a mass of notes such a man as Dalton did not deduce much that was new to science, and theoretically important.

Some time prior to the publication of his "Observations" he had thought of qualifying as a lawyer or physician; but changed these views on obtaining the more congenial employment of Professor of Mathematics and Natural Philosophy in the New College, Mosley Street, Manchester, to which city he removed, and there spent the remainder of his days. He became a leading member of the Manchester Literary and Philosophical Society, to the Transactions of which he contributed a series of papers containing the results of original researches of the greatest value to science.

In 1803 he published an essay "On the Tendency of Elastic Fluids to Diffusion through each other;" and a second "On the Absorption of Gases by Water and other Liquids;" the latter containing the first announcement of his discovery of the laws for combining proportion, and the germ of his celebrated hypothesis, *the atomic constitution of matter*. In this he employed his usual mode of illustration, representing the particles of the liquids by one kind of dot, and the particles of the gases by another kind, showing how fully a belief in the atomic theory of formation had taken hold of his mind. He took a mechanical view of the absorption of the gases by liquids; but it was asked, "If this mingling were a mechanical matter, and not chemical action, how does it happen that water dissolves its own bulk of one gas, carbonic acid, and only three per cent. of its own volume of another, such as oxygen?"

Dalton saw this difficulty, and replied, "Why does water not admit its bulk of every gas alike? This question I have duly considered, and though I am not yet able to satisfy myself completely, I am nearly persuaded that the circumstance depends upon the weight and number of the ultimate particles of the several gases, those whose particles are lightest and single being least observable, and the others more, according as they increase in weight and complexity." To this he added a table of the relative weights of the ultimate particles of gaseous and other bodies, and this was the first attempt at a table of *atomic weights*.

The atomical philosophy has been alleged to be atheistical, or allied to atheism; but the learned Dr. Cudworth says it existed before and without atheism, and that Democritus and Leucippus are to be regarded as the first inventors of atomical philosophy. Of the theory in *chemistry*, though first noticed by Higgins, of Dublin, in 1789, and by Richter, of Berlin, four years later, the doctrine was neither fully expounded nor completed till Dalton published his "New System of Chemical Philosophy" in 1808.

Five years before this he had lectured on the subject in Manchester and at the Royal Institution of London. In 1804 he fully explained it to Dr. Thomson, of Glasgow, who spent a few days with him in Manchester, and in 1807 he lectured publicly on the subject in Edinburgh and Glasgow. From thence till 1810 he was chiefly occupied in the prosecution of analyses to verify his theory, and in teaching mathematics, though he was not a fluent speaker, and did not possess much talent for teaching. He succeeded, however, in proving his theory, in direct opposition to Berthollet, who maintained with great ability the doctrine of indefinite affinity, or the opinion that substances disposed to combine united in every possible proportion; that the several compounds formed by varying proportions of the same ingredients are all multiples of the first.

Dalton had ever round him in Manchester a circle of appreciating friends, who more than once offered to provide him with a competence to the end that he might give his undivided attention to the pursuit of scientific investigations; but these offers he declined. In 1814 his portrait was painted by Allen, and engraved for distribution. In 1822 he visited Paris, and was introduced to La Place and all the more distinguished of the French philosophers. He was invited to attend the meetings of the Institute, and was everywhere treated with such distinction that, though naturally retiring and modest, he said on his return home: "If any Englishman has reason to be proud of France, I am that one."

In 1826 the Royal Society of London accorded to him the royal gold medal, of fifty guineas value, placed at their disposal by George IV. He attended the earliest meeting of the British Association for the Advancement of Science, held at York in 1831. Its next assembly was at Oxford, in 1832, when the degree of D.C.L. was conferred upon him by the University. When the Association met at Cambridge in 1833, its president, Professor Sedgewick, closed a speech full of compliment to Dalton by announcing that "His Majesty William IV., wishing to manifest his attachment to science, and his regard for a character like that of Dr. Dalton, had graciously conferred on him, out of the funds of the Civil List, a substantial mark of his royal favour." This "mark" was raised to £300 per annum in 1836. For his marble statue at Manchester, by Chantrey, £2,000 was subscribed;

and, when in London, he was presented to William IV. by Lord Brougham, then Chancellor. In 1834 he was in Edinburgh, where fresh honours awaited him. The University conferred upon him the degree of LL.D.; the Town Council gave him publicly the freedom of the city, and he was elected a Fellow of the Royal Society of Scotland.

In the seventieth year of his laborious and useful life he had a paralytic stroke, which left his right arm powerless, and also deprived him of speech. Prior to this very year he had always enjoyed robust health, and was fond of outdoor exercise. He had made a yearly pilgrimage to his native mountains of Cumberland and Westmoreland, and never failed to climb, with all a borderer's delight, Skiddaw and Helvellyn. Every Thursday morning he was wont to devote to the old English game of bowls. He was methodically regular in attending twice on Sunday the meetings of the Society of Friends; and on the same day for more than forty years he dined at the house of a friend. Dalton was "a simple, frugal, strictly honest, and truthful man. For the independence, gravity, and reserve of his character, he was doubtless much indebted to his birth as a Cumberland yeoman, and his long connection with the Society of Friends."

A second and third paralytic stroke greatly increased his infirmity, yet, singular to say, he was able to be present at a meeting of the Council of the Manchester Literary and Philosophical Society in May, 1844, when he was presented with an engrossed vellum copy of a resolution of that body, passed at their annual meeting. It recorded "their admiration of the zeal and perseverance with which he has deduced the mean pressure and temperature of the atmosphere; the quantity of rain for each month and for the whole year; with the prevailing duration and force of the wind at different seasons in this neighbourhood, from a series of *more than two hundred thousand observations*, from the end of the year 1793 to 1844, being the period of half a century."

Dalton received the resolution sitting in a chair, and was unable to articulate a reply, though his face expressed the deepest emotion. This was on the 19th of May, and eight days after, he expired. His remains were interred in the cemetery at Ardwick Green. By his will he had left £2,000 to endow a Dalton Chair of Chemistry in the University of Oxford; but before his death he revoked the bequest by a codicil, for the purpose of bestowing the money on certain persons who had befriended him in his earlier and more dependent years.

THE LATHE.—VI.

By Henry Northcott.

SLIDE-RESTS: THEIR USES AND ADVANTAGES (*continued*).

There is yet another form of slide-rest described in the old book I have mentioned, devised especially for the production of spheres, and this rest is worked out into a very neat instrument. To produce a spherical curve is, of course, no more difficult than to produce a straight line; indeed the former is the easier, but the requirements of the spherical slide-rest do not appear to have been so easily understood. In the spherical slide-rests, illustrated by Figs. 19, 20, and 21, there are two slides—a slide for producing a circular movement, or movement around a centre, and a slide for obtaining a right-line movement, or movement from the centre. The whole of this rest is of metal, as the former ones are, and the lower part or baseplate A is made to fasten down upon the lathe-bed, the projecting piece B going down between the two cheeks of the bed to act as a guide in keeping the position of the slide, and it is held in place by a capstan-headed bolt C, with a cross-piece or bridge spanning the lathe-bearers below. All this is much the same as in the previous examples of ordinary rests.

The top part of A is trued up and rendered very smooth, and also perfectly parallel to the lathe-bed surface when the rest is in place. Accuracy of workmanship, it may be remarked, is absolutely essential to ensure the satisfactory action of all kinds of slide-rests. The baseplate A is rectangular, but its upper part D is formed circular by merely turning off the corners, and this leaves a circular plate with a true flat surface. Upon this circular table is placed a circular plate of brass, F, of the same size, and this brass plate is fitted nicely down upon the other surface: and by means of a conical pin going through the brass plate and screwing into the plate below, the two surfaces are kept in close contact. The conical pin also acts as an axis or centre around which the circular disc may rotate. The extreme edge of the disc should be graduated or divided into 360 for convenience of adjustment, by reading off the extent of movement of the disc, as compared with the stationary plate below, which carries a zero mark or line to enable the movement to be easily compared. The broad edge of the disc is furnished with fine teeth, so as to convert it into a worm-wheel, and an endless screw or worm, with corresponding thread, is carried in brackets attached to the stationary part A, and is arranged to gear with the teeth on the edge of the disc F. This arrangement of worm-wheel and worm, or tangent-screw, is best shown in Fig. 21, which is a plan of the entire rest. From this view it will be seen also that the axle of the tangent-screw is continued outwards towards the operator, and is furnished with a small winch-handle, by means of which the screw is caused to rotate. The top surface of the worm-wheel is also rendered true or accurately flat, and two side pieces or cheeks, H, H, Fig. 19, are fastened down upon it, forming a female slide for the part K. The shape of these cheeks, and the manner in which they are placed upon F, are plainly shown in Fig. 21, where are seen the heads of the four screws which are used to fasten the cheeks down in their places. K is a male slide, and it is continued upwards in a spiral form, so as to terminate in a narrow edge suitable for carrying a cutting tool. This form of support gives great solidity and is rather ingenious, but it is somewhat cumbersome, and is now discarded. The slide part of K is rather different from the slides previously illustrated, inasmuch as the male and female slides are now reversed, but the arrangement is clearly shown in the figures. The traverse of the slide is brought about by means of a screw, and the top slide carries a small pointer *a*, Fig. 21, which slightly projects out over the slide cheek, the edge of which is graduated. These graduations are for the purpose of adjusting the radius of the curves to be produced. The tool-holder portion of this slide-rest is of a very simple construction. The tool is placed upon a narrow edge, being the extremity of the part K, and is held down by means of two clamps and screws, *n*, *n*.

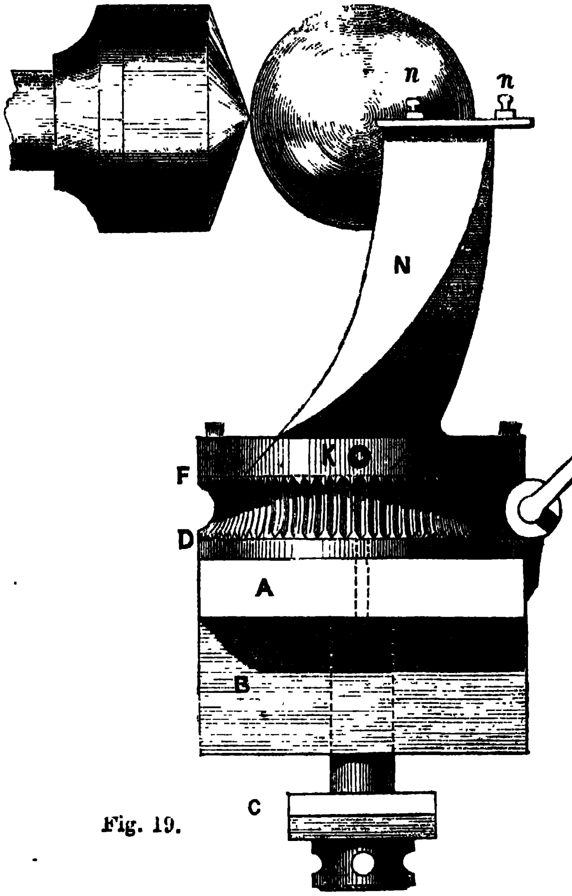

Fig. 19.

The action of this kind of slide-rest is obvious from the several figures, which not only illustrate the construction of the rest, but its position relative to the work it is designed to execute. It will be seen that the centre of the slide-rest, or the centre of the axis around which the tangent-wheel F rotates, is placed immediately underneath the centre of the required sphere or curve; that is to say, a plumb-line passing down through the centre of the sphere would also pass through the axis of the slide-rest. The tool being in its place, the depth of cut and the size of the sphere would be determined by the movement of the slide K, which has the effect of regulating the distance of the tool's point from the same plumb-line, or rather from the centre of the sphere. The traverse of the tool's point, or its movement along the surface of the work in the required curve, is obtained by moving round the tangent-wheel F, carrying the other slide by means of the endless screw at the side.

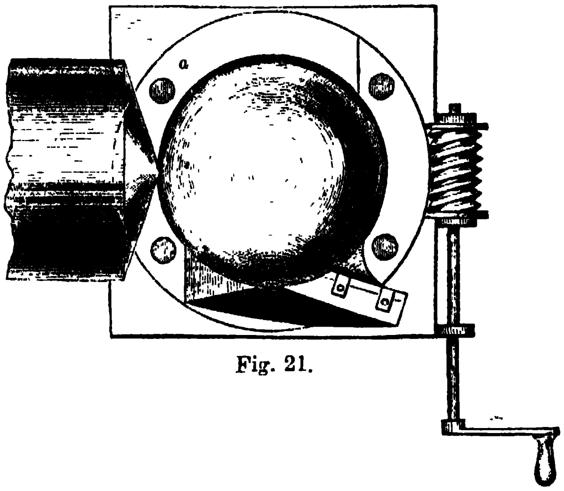

Fig. 21.

No kind of spherical slide-rest will produce a sphere from the solid at one operation, as a small part must be left as a support. In the example before us in Figs. 19, 20, and 21, the sphere is shown very nearly but not quite complete. The whole of the outside of the curve is described and easily formed on the material, but a small neck is shown by which the ball is connected to the main portion of the material from which it has been cut. In practice no inconvenience results from the necessity of leaving a connection, as the part finally left is extremely small. It is usual to leave rather a large neck, so long as any heavy cuts remain to be taken away from the ball or any great strain put upon it; but when the heavy work is done and the finishing cut has to be taken, the neck may be reduced in size, and after the ball is otherwise completely turned, the neck may be still further reduced in size. By using a sharp-cutting hand-tool and running the lathe fast, the ball may even be completely severed from the stock and the sphere detached in a perfect form.

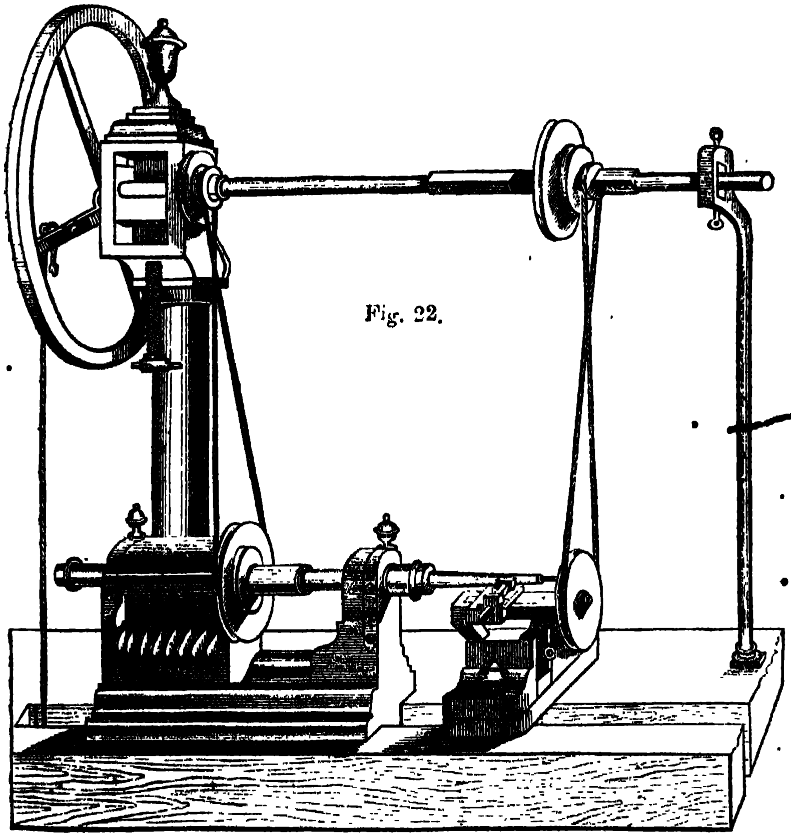

Fig. 22.

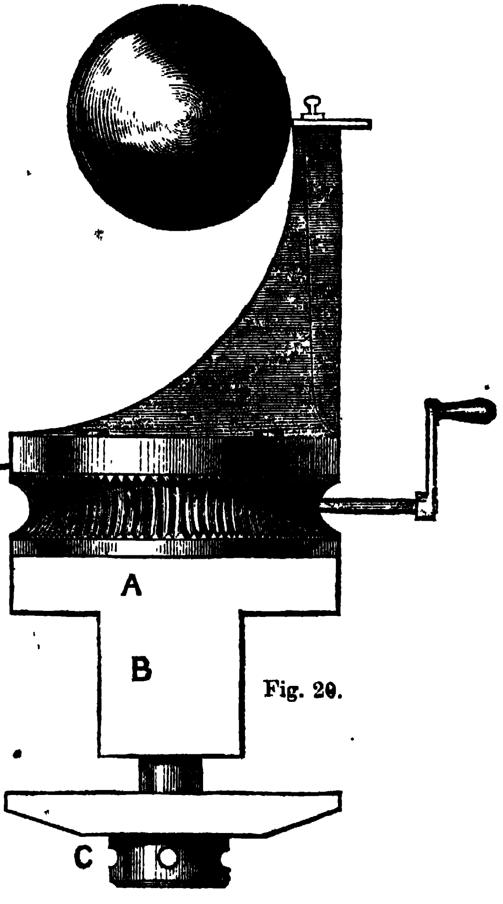

Fig. 20.

I have been at the pains to describe these old forms of slide-rest with some particularity, as it does not appear to be understood that the slide-rest is so old an invention. Most writers attribute the invention to Maudslay, the celebrated English mechanical engineer, but this is evidently incorrect.

Having the slide-rest, which to a great extent superseded the workman's hand in the execution of the work, but still required to be actuated by him, the next improvement was to render it unnecessary for the workman even to turn the winch-handle, and to make the motion of the tool automatic by connecting the traverse screw in some way with the lathe-spindle or some part of the lathe mechanism. This is effected in various ways, and one of the earliest schemes is shown at Fig. 22. The motion in this case is derived from the foot by the means already mentioned, and this motion is first given to an overhead shaft, which in turn drives the lathe-spindle through a crossed gut or cord and a pair of stepped V-pulleys. The overhead shaft carries another stepped V-pulley, for driving a pulley which is placed upon the end of the traverse screw of the slide-rest instead of the usual winch-handle. The relative speed of the lathe-spindle, the overhead shaft, and the slide-rest screw, can be adjusted by placing the guts upon the various grooves of the pulleys, so that the fineness of the cut may be regulated to the work in hand.

FISH CULTURE.—VI.

By Greville Fennell.

DETRIMENTS TO FISH CULTURE—BREEDING PONDS AT STORMONTFIELD.

Mr. Wilhelm Hartman has contributed much valuable information to the *Transactions of the German Fishery Society*, and as his language is simple and his conclusions coincide for the most part with our own, while they give us the last information upon a subject now of great European interest, we give an abstract from his paper, making those comments we deem requisite.

Whenever the question of fish culture concerns attempts at propagation which may be useful for our domestic economy, we always do best when we closely adhere to natural history, and especially to the history of the development of the object to be treated. More than anywhere is this course to be observed in fish rearing; and we do not scruple to assert that the various incorrect views on this branch of animal culture, the over and under estimation of the importance which was attributed to it in respect to natural economy, that, finally, the comparatively not very brilliant results which have been hitherto attained, have mainly their grounds in the fact that trouble was not taken to study the nature, the development, and mode of life of the fish by personal observation and practice, or even to obtain information from those who were acquainted with them.

If we observe the propagation of salmon in natural freedom, as did Gehin and Remy that of trout, we see, in the spawning time the female ascends the river followed by several males. At a suitable place she stops, hollows out a shallow, deepening in the sand or gravel by movements of the tail, lays a heap of eggs in it, and swims further upwards. One of the males, usually the strongest, swims quickly there, and sprinkles his milt over the eggs. The impregnation of the eggs, then, occurs, not as with mammalia and birds, through the act of copulation, but only after they have been laid. Here the first loss immediately follows, as about 30 per cent. of the eggs laid are not touched by the fertilising milt, and therefore cannot come to a development. A second loss occurs almost at the same time; as those males which cannot attain to the fructification of the eggs fall upon them ravenously and devour a part of them; this may be reckoned at 10 per cent. The remaining 60 per cent. are exposed to the attacks of innumerable enemies to which they fall a prey—fish, crawfish, water-mice, aquatic birds, etc., and lastly to be frozen, such, of course, being only the eggs of winter fish, to which, however, the most precious sort belong. Thus there are about 30 per cent. hatched out of the eggs laid, but now the destruction goes on seriously. The eggs were at least somewhat protected by a tolerably tough elastic cover, and the sand partly covering them; the helpless young, on the contrary, lie three to six weeks with the most easily-injured navel-bag without protection, exposed to their weakest enemies—small larvæ, insects, water-beetles—open on the gravel of the bottom; and it will be well if, at the time when the little fish, on the absorption of the navel bag, begin to swim about, to feed, and become self-providing, there remain half a dozen of those hatched out. In consideration of such enormous losses, the task of fish culture, to which the somewhat inapplicable name of artificial is given, becomes sufficiently evident. It consists in protecting the material capable of development which Nature produces in a colossal quantity (a salmon, *e.g.*, lays annually 25,000 eggs) against the losses to which it is exposed in open waters. Of special importance is this for salmon and trout, because with them the most dangerous period—that of the navel-bag—lasts the longest, and also because these fish have a higher value than the others. It is therefore natural that more trouble and a greater outlay of capital should be applied to their increase. To those who take an interest in the various details, we[*] recommend a journey to Freiburgh during the winter months to inspect the fish culture of the Burgomaster Schiester.[†]

Visitors to Sunbury should inspect the nursery near the lock, in which Messrs. Buckland and Ponder rear their fish after hatching out for the stocking of the Thames. Nurseries should be carefully watched, and this one, although of great extent, is covered with wire netting to prevent the kingfishers—who invariably find out where the young of trout are—from picking them up. The youthful jack is likewise an insidious enemy, and will introduce himself amongst the young through any aperture which will admit an eel. Eels are enemies of all fry of fish. The carnivorous beetle should be searched for with a small mesh-net amongst weeds. The larvæ of the dragon-fly are also very destructive.

The Museum of Economic Fish Culture being an educational establishment, yet wholly supported by private enterprise and private funds, and without any apparent hope of Government aid, is the most accessible place to obtain every information upon fish culture. There is always some one in attendance who is skilled in the process; and Mr. Frank Buckland is ever ready, either personally or through his secretary, to reply to any queries directed to him relating to this interesting subject. The museum is, however, the place for fish-hatchers to compare, note, and deduce useful facts.

This is our conclusion with regard to many establishments, and that at Stormontfield especially, that we are breeding small fish for the big ones to eat. We fully agree with Mr. John Richardson that the kelts eat the parrs, but here we have no remedy, and Nature must take her course.

Mr. Thomas Ashworth was one of the most distinguished of our pioneers of salmon culture in all its aspects, and Galway the best managed and perhaps the most productive fishery in the kingdom.

Mr. Russel truthfully observes that whatever doubts may rise as to the good of introducing certain fish into rivers to which they have heretofore been alien, and thus give the vested inhabitants of those rivers other competitors for their food, there can exist none in regard to the salmon, as he is not a formidable competitor with any other species as to food, and moreover is the most valuable and desirable of all fish. Of course there is, in the case of the salmon, the heavy drawback arising from its being migratory and vagabond in its instincts and habits; but still much can be done, and not a little has been done, to increase the stock of salmon by semi-artificial propagation, and semi-domestic rearing. It is obvious that salmon *ab ovo*, and before that, up to the age of puberty, are, in their natural abodes, exposed to very great perils; thus, besides those enumerated elsewhere, there is the loss by spawn being deposited during floods, when the rivers are high, in positions where, when the waters fall, it is destroyed by frosts and drought, or trampled under foot of man or beast—an evil of late very greatly increased by the extension of land drainage, especially the hill or open drainage, which causes the rivers both to rise higher and to sink lower and more rapidly.

What breeding-ponds have already done and have shown *can* be done, in applying a remedy at this point is striking. Mr. Francis Francis gives us the early history of the operations in the breeding of young salmon at Stormontfield. A gentle slope from a mill-lade, running parallel with and sixteen feet above the Tay, was chosen, whence a sufficient supply of water could be obtained. Three hundred boxes were laid down in twenty-five parallel rows, each box being partly filled with clean gravel and pebbles, and protected at each end by perforated zinc. Filtering beds were formed at the head and foot of the rows, and the boxes were charged with 300,000 ova by the 23rd of December. On the 31st of March the first ova were hatched. A pond had been provided for the fry; this pond was 223 feet long by 112 feet in the broadest part. It was subsequently found to be far too small. By June the greater part of the fry were admitted into the pond, being then about an inch and a half long. There they were fed with boiled liver daily, and, on the 24th of May, or nearly twelve months after their being hatched, a large portion of them having assumed the smolt scale, left the pond, and commenced their descent to the sea, an equally large number remaining behind, and showing no disposition to assume the migratory dress of the smolt. Many of the smolts which then migrated were marked by the cutting off of the adipose fin, and a large number of them were re-taken ascending the river again, at various periods up to August, in the form of grilse, and varying in weight from 6 lb. to 9 lb., according to the time they had remained in the salt water—thus proving the disputed question as to the rate of growth of the salmon. From 1853 to 1862 the boxes were stocked five several times. One of these years (1854) proved a failure. It was found impossible to stock the boxes oftener than every other year, owing to the limited accommodation for the fry. Great benefits must have accrued to the Tay from these operations, but it was rendered impossible to estimate them, by reason of the prejudice and ignorance of the fishermen, who failed to send notice to Mr. Buist of the marked fish re-captured, so that the proportion of fry that returned to the river as grilse and salmon could not be computed.

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[*] Wilhelm Hartman in the *Transactions of the German Fishery Society*, 1871.

[†] The eggs of fish were distributed from Huningue with various results. The most successful place was Wolfesbrunnen near Heidelberg. There are many localities in England where the same thing might be done if fish culture were carried out on a scale in comparison with its requirements.

PHOTOGRAPHY.—VI.

By J. C. Leake.

POSITIVE PRINTING.

The production of positive proofs upon paper—that is to say, of pictures which have their light and shade in their proper and natural order instead of being reversed (as is the case in negative pictures, such as we have before described), is of course a matter of much importance; as these being the final result of the photographer's operations will afford the opportunity of judging of the success or non-success of his work. There often prevails among even professional photographers an idea that printing a photograph is a very simple and easy matter, and frequently so little care and skill are expended in this portion of the work, that that which has been given to the production of the negative is completely wasted. It is perfectly true that a good print may be obtained by a person who is unskilled in making a negative, but it must be remembered that the chemical processes involved are as delicate and subtle as those employed in the first-named process; and, if pure, bright, and brilliant prints are desired as well as permanent results, the same care must be given to one as to the other. As is the case with respect to the production of negatives, there are many methods employed in making positive prints; but, for the sake of simplicity and clearness of description, we shall here confine our instructions to those employed in what may be termed the standard process—namely, that by which the proofs are obtained upon albumenised paper. In outline this process is as follows. A sheet of paper of suitable quality is selected, and coated with albumen or white of egg, to which is added a suitable chloride, such as that of sodium or ammonium. After a few minutes the sheet is removed from this bath and dried. In this state it is totally insensitive to light; but upon its being floated upon a solution of nitrate of silver, the chloride retained upon the surface by the albumen combines with the silver in the bath, forming a chloride of silver, which rapidly blackens under the sun's rays. A sheet of this paper is placed under the negative in a suitable frame, and exposed to the action of light, when of course those parts of the negative which are the least dense allow the rays to reach the sensitive paper which they darken; while those which are protected by the opaque portions retain their original whiteness. This change is effected in exact proportion to the varying shades in the negative; and the result is a picture true to the light and shade of nature, and of the most exquisite fineness and delicacy, both of outline and gradation.

In this state, however, the picture is not only liable to fade from the darkening of the whole surface, but it is of an unpleasant colour; the alteration of which necessitates what is termed the toning process. The print is well washed in order to remove any unreduced nitrate of silver which may remain upon its surface, and is afterwards immersed in a solution containing chloride of gold. In this it rapidly assumes a pleasing colour, which varies according to the time during which the action is continued. All that now remains is to fix the picture by removing the unaltered chloride of silver, which is effected by placing the proof in a solution of hyposulphite of soda. The proof must now be thoroughly washed to remove the fixing salt, when it will be ready for mounting. From these remarks it will be seen that although the process of printing is simple, some care and skill are required in the various manipulatory details, and these we shall now proceed to describe.

Although it is scarcely to be expected that the amateur will prepare the albumen-coated paper for his own use, seeing that it may now be readily procured at a less cost than he could make it for himself, we here give the requisite formula, in case he should elect to do so, merely suggesting that without a proper room heated to a high temperature, he will find it a tedious and difficult process. With respect to the paper employed, it should be of fine quality, smooth surface, and of moderate thickness. Papers of foreign manufacture are mostly used for photographic purposes, and the two varieties known as "Rive" and "Saxe," are considered the best and most suitable. Of these the Rive is best for portrait work, while for landscapes or pictures of large dimensions Saxe is preferable, on account of its clearness and freedom from spots and other defects. The method of preparing the albumen is as follows:—Take of pure albumen obtained from fresh eggs, and free from yolk, fifteen ounces, which place in a wide-mouthed bottle capable of holding at least thirty fluid ounces. Dissolve in two or three ounces of distilled water one hundred grains of chloride of ammonium, and mix it with the albumen. Now carefully select and wash about half a teacupful of small smooth stones, about the size of peas, and place them in the solution. The bottle should now be carefully corked, and the whole agitated until it is entirely converted into froth.

Upon the perfect beating of the albumen the success of the operation mainly depends, as, if this be not thoroughly effected, small shreds of membrane remain upon the surface of the paper and cause streaks and stains. When thoroughly beaten the albumen should be poured off into a tall vessel, and allowed to settle for several hours before use. The stones left at the bottom of the bottle may be washed and kept for future use, as by cutting through the liquid they materially assist the perfect mixing of the albumen and the water and salt. When thoroughly settled the solution should be poured into a flat dish of the required size, to the depth of about half an inch, and carefully skimmed by means of a slip of paper. A selected sheet of paper should then be taken by two of the corners, and being bent into a sharp curve, the centre part should be laid upon the solution, the corners being allowed to follow gently down, taking the utmost care to avoid air-bubbles. Of course, one side only is coated in this way, and care must be exercised in keeping the albumen from flowing over the edges and on to the back of the paper. After having remained upon the solution about one minute the sheet should be removed, and suspended by two corners until dry. As we have before remarked, the albumenising of paper is a difficult operation, and we should advise the operator to procure that which is ready prepared, wherever possible, rather than undertake to perform it for himself.

The next operation will be that of sensitising the albumenised surface, and preparing it for the action of light. We may here observe that although the paper will rapidly darken under the action of light after sensitising, yet it is not nearly so delicately sensitive as the collodion film before described; and consequently much more light may be admitted to the room in the former than in the latter case. The albumenised paper may be rendered sensitive by floating it for three minutes upon a solution prepared as follows:—Take of nitrate of silver five hundred grains, to which add ten ounces of distilled water, and dissolve. Filter and pour it into a flat dish to the depth of half an inch, and remove any scum or dust with a slip of paper as before described. The paper having been cut to the required dimensions, should now be laid face downwards—that is to say, with its albumenised side—upon the solution, precisely as directed for albumenising, and with the same precautions as to the avoidance of air-bubbles. Having remained upon this solution for the space of about three minutes, it should be raised at one corner by means of a pair of bone forceps, and gradually lifted completely off the solution. It should then be well drained into the dish, and finally suspended by one corner to dry, removing the last drops of solution by means of floating paper applied to the lower corner. When dry the paper will be sensitive to light and ready for exposure in the printing frame.

The printing or pressure frame generally in use is a very simple and inexpensive piece of apparatus, consisting of a frame of wood, into which is fitted a square of thick plate glass. Upon the edges of this enclosing frame are hinged two or more arms of wood, into which screws are placed in order to ensure perfect contact between the sensitive paper and the negative. A backboard of wood, hinged together in one or more places, is made to fit into the frame upon the plate of glass, and the screws are then adjusted so as to secure the whole in absolute contact. In order to print a picture, the negative (having been first cleaned at the back) is laid upon the plate glass face upwards, in such a position as to allow of the inspection of one part of the picture while printing, without the disturbance of the other. A piece of sensitive paper rather larger than the negative is then laid sensitive side downwards upon the negative plate. A piece of felt (felt carpeting will answer) or a few folds of cloth or blotting-paper are then placed over the paper in order to equalise the pressure, and ensure absolute contact. The backboard is then placed in position, and the arms having been secured, the screws are adjusted, and the whole tightly compressed. The amount of pressure required is not considerable, but perfect contact between the paper and the negative must be secured. The whole must then be exposed to the action of light, either in the sun or in open daylight. If the light be good a very few minutes' exposure will produce a marked difference in the appearance of the paper, the unprotected portion becoming rapidly darkened. If the negative be of good quality and of average density, as soon as the edges of the paper show signs of bronzing, the pressure frame should be removed to a room in which the light is only moderately brilliant, and one half of the back unscrewed. The backboard and felt as well as the paper may now be turned back, and the progress of the printing may be inspected. When the impression is slightly darker than is required in the finished picture, the paper may be removed from the printing frame and placed in a portfolio for further treatment.

The requisite number of prints having been thus printed, the edges should be roughly trimmed up to the size of the negative, when they will be ready for the further operations of toning and fixing. In trimming the proofs care should be taken to preserve every fragment of sensitised paper, as the whole of the nitrate of silver with which it is impregnated is easily recovered, and of course valuable. A large dish should be provided, as well as a good supply of clean water, and if possible a large pan or tub into which the washings (which will contain a good quantity of nitrate of silver) may be poured and preserved. The dish should be about two-thirds filled with clean water, and the prints immersed one at a time and well rinsed, of course taking care not to tear or injure them. When all have been thus treated, the first washing should be poured off into the waste tub and the dish again filled, continuing the rinsing with the same precaution as before. The second washing having been effected, and the water having been preserved as before, a third quantity should be placed in the dish and a small quantity of common table salt added, which will convert any remaining nitrate of silver into chloride, an important point when permanency is desired in the finished print. If this third washing solution be poured into the waste tub, it will assist in precipitating the nitrate of silver; a matter of which we shall treat further on.

It will be observed that the proofs will have assumed a very unpleasant colour under this treatment, most likely a brick red, and in order to remove this, they must be submitted to the action of the toning bath, in which they may be brought to almost any shade which may be thought desirable. The toning bath is prepared as follows:—Take of acetate of soda fifty grains, which dissolve in sixteen ounces of distilled water. Dissolve three grains of chloride of gold in two ounces of distilled water, and pour the latter into the former solution, stirring with a glass rod. This solution should be prepared at least twelve hours before use, and it may be used over and over again, merely adding small portions of the last-mentioned gold solution as it begins to work too slowly. It is, however, better to allow at least the time we have mentioned to elapse after the addition of the gold before attempting to work with it. If this precaution be neglected it is very apt to work irregularly, especially if the quality of the paper employed be not of the best.

Having poured into a deep dish enough of this toning solution to float the pictures freely without touching each other (say about two inches), proceed to remove them one at a time from the water into the solution, thoroughly soaking each one before the next is introduced. Not more than five or six should be toned at once until the operator has acquired some experience at this kind of work, or some will inevitably be spoiled by over or unequal action. The proofs must be kept constantly moving, and be continually turned over and separated, for wherever they adhere the toning action will stop, and ugly red patches will result. In a few minutes the toning process will be observed to have commenced, the proofs gradually passing from a red to a brown tone, then from brown to purple, and finally to black and grey. The coloration of the proofs should be allowed to continue until rather more advanced than is required in the finished print; as the fixing process will restore a little of the original redness. When the toning is judged to have proceeded to the required extent, the proofs should be removed to a dish or pan containing clean water, and thoroughly washed, in order to remove the gold solution and stop its further action. If the whole batch of prints have not been toned at once, the remainder may now be operated upon as before described; leaving the first batch to await the fixing process until such time as the whole are ready. The great evils which the operator has to guard against in this process are unequal and over-rapid toning, neither of which he is likely to encounter if the directions given above are strictly carried out. In very hot weather the bath frequently works very quickly, and when this is found to be the case it may be freely diluted with distilled water until it becomes easily manageable. If, on the other hand, it works too slowly, it may be warmed to sixty or seventy degrees, and in very cold weather it must be kept fully supplied with gold, when quick working and brilliant tones are desired.

The proofs will now be ready for the fixing process, which is one of the utmost importance; as the permanency of the work depends very much upon its proper performance. The solution used for this purpose is one of hyposulphite of soda, which is made in the following proportions:—Hyposulphite of soda six ounces, common water one pint. For use pour into a dish enough to freely float the prints, and keep them moving therein at least fifteen minutes.

The great point to be attained in this process is to subject all parts of each proof to the action of the hyposulphite solution in order to remove the whole of the sensitive silver salts, consequently the prints must be kept constantly in motion, the manipulation being precisely similar to that above described as required for the toning process. As soon as the fixation is completed, the prints must be thoroughly washed in as many waters as may be convenient, in order to remove the whole of the hyposulphite. As may be imagined, this is a difficult matter; but it is one upon which the success of the whole depends. The smallest trace of this salt will, if left in the print, inevitably destroy it sooner or later, and consequently its removal as completely as possible is absolutely essential. Many mechanical contrivances have been introduced from time to time to effect this, but practical experience has proved that nothing is so well adapted to the work or so really effectual as proper washing by hand. After as many as ten washings have been given, directly after the prints have been taken out of the bath the whole batch should be placed in a large pan to soak for some three or four hours. They should then be thoroughly washed and drained for some minutes, and again immersed in clean water for a like time. After this treatment has been repeated several times a final rinse should be given in water heated to about one hundred degrees; when they may be blotted off and dried for mounting.

The operation of printing may now be considered as completed, and the proofs may be mounted as the taste of the operator may suggest. In concluding this section of our subject we may offer some suggestions upon one or two points connected with the printing process. In the first place, where really first-rate work is required, the sensitising, exposure, toning and fixing processes should all be performed upon the same day; especially during the hot months of summer. Secondly, the strength of the nitrate-of-silver bath is a matter of vital importance, and as it is rapidly reduced when in use, it must be constantly replenished with fresh crystals. The discoloration which will occur after floating the paper may be removed by agitating after the addition of a little kaolin or China clay. The utmost care must be exercised in order to prevent any contamination of the paper, prints, or chemicals with the hyposulphite of soda; and more particularly is this caution necessary with respect to the toning bath.

As in the case of the collodion process, we have here omitted all reference to failures, leaving these and their remedies for consideration in our next article, as well as some modifications of the printing processes which are sometimes required.

MINING AND QUARRYING.—XIX.

BY GEORGE GLADSTONE, F.C.S.

COPPER.

ABUNDANCE AND DISTRIBUTION OF ORES—HOW MINED—CHEMICAL COMPOSITION OF PRINCIPAL ORES—DRESSING—ASSAYING.

UNLIKE tin, with which metal it is so much associated in Devonshire and Cornwall, copper is very widely distributed in Nature. In the British Isles the principal localities where it occurs, besides those already named, are North Wales and Ireland; but the ore has at times been worked to a considerable extent in Staffordshire and Shropshire also. Many of the richest home mines have been worked out; and it is beyond a doubt that were it not for the large foreign supplies, the price of pure copper would have risen considerably during late years, instead of having declined, as has been the case.

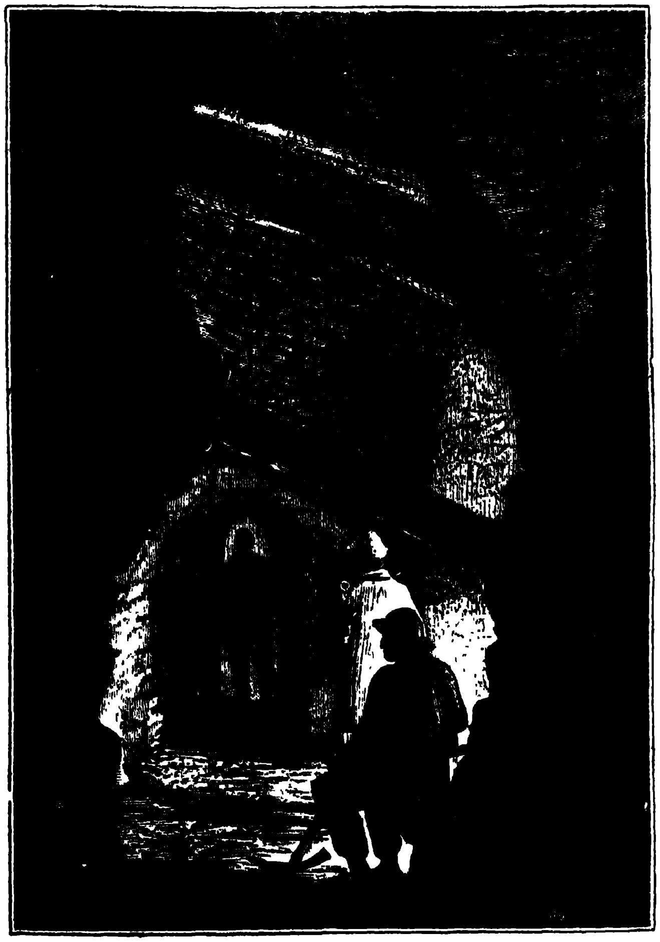

Fig. 13.—WORKINGS IN FOWEY CONSOLS MINE.

Very rich deposits have been discovered from time to time in various parts of the world; and as the facilities increase for conveying the ores to the places of shipment, these foreign supplies enter into competition with those of the British mines. Cuba, Spain, Italy, Australia, Chili, the Cape of Good Hope, and other countries which have the advantage of being in easy communication with England by sea, all supply ores in large quantities; and several others would also enter into the competition, were it not for their less favourable situation. Siberia, for instance, possesses very extensive deposits, and so does the interior of Canada, where indeed there are some of the most remarkable known.

The ore generally occurs in lodes or veins in the palæozoic and metamorphic rocks; and so far as English mining is concerned, the most typical examples of mining for copper are to be found in Devonshire and the adjoining county. The Devon Great Consols mine has been in late years the most successful of all the copper mines in that district; but there are several others which are conducted on a very large scale, and which have yielded immense returns of ore.

The plan upon which copper mines are managed underground is so similar to that already described under the head of "Tin," in Article XV., that little need be added; one or two additional particulars may, however, serve to give an idea of the magnitude of some of these works, and a more intelligible one of how they are carried out. The adit level, and the purpose for which it is made, have been described. A general system of drainage, common to the whole of the district, is sometimes adopted by miners; and such adits as these are grand specimens both of human industry and engineering skill. Thus, the Great Adit, as it is called, which carries off all the superfluous waters from the mines of Redruth and Gwennap, is (including its branches) about thirty miles in length. * It may readily be imagined, too, that the most powerful machinery must be required to pump up the water to the adit, from the bottom of the deep mines, such as the Tresavea, the workings in which have already been carried to a depth of more than 350 fathoms. Indeed, ever since the application by Watt of steam to pumping machinery, the Cornish engines have been celebrated for the amount of work they perform in proportion to the consumption of fuel; and a healthy rivalry in this particular is maintained by registering the duty of the several engines, and publishing the results periodically.

The quantity of timber employed underground is prodigious. Sometimes baulks of timber are fixed crosswise between the walls of the lode, to prevent them from collapsing, as in Fig. 13; but if the rock is tender, the galleries are timbered in a more methodical manner, as shown in Fig. 14. The shafts are frequently divided into segments, and lined, and the boxes for raising the ore made to run in grooves, as is commonly the case in deep coal mines, but the old-fashioned kibble or bucket is still in use. Fig. 13, already referred to, illustrates a part of the workings in the Fowey Consols Mine: the wide space has been worked out, because there the lode indicated sufficient promise of ore; but the next portion, being less encouraging, has been left, and a gallery no larger than is necessary for the purpose of exploration has been driven through it.

Copper occurs in Nature in several combinations; but the ores of commercial value may be reduced to three classes—the sulphides, the oxides, and the carbonates. The former includes the grey and yellow ores, the grey being comparatively rare, while the yellow is the most prevalent of all, being familiarly known as copper pyrites. Though containing usually but a small percentage of metal, it is the ore upon which our miners principally rely. The carbonates may also be distinguished by their colours; the blue is termed azurite, and the green malachite, by mineralogists. The green variety is the best known, on account of its capacity of being cut and polished, when it furnishes a highly ornamental stone, the varieties of tint and the concretionary forms displayed being very beautiful.

The grey cuprous sulphide (Cu_2S) should contain theoretically 79·8 per cent. of copper, but it is rarely altogether free from other minerals. It not unfrequently includes a considerable proportion of arsenic, iron, and silicon. The yellow sulphide, commonly called pyrites, is a compound of the former with the ferric sulphide (Fe_2S_3), so that it rarely contains more than about 10 per cent. of metallic copper; but it frequently occurs in such large masses as to make up by quantity for the comparative lowness of its produce. The Parys Mine, in the Island of Anglesea, which proved exceedingly remunerative for a long term of years, consisted of this cuproso-ferric sulphide alone; and so great was the mass of ore, that huge caverns, extending through the Parys Mountain in all directions, remain to attest the bulk of the ores which were removed during the period of the mine's prosperity. In foreign parts also there are several equally remarkable deposits of this particular ore. That of Rammelsberg, in the Harz Mountains, is believed to have been worked uninterruptedly for the last 900 years. The term lode would be equally inapplicable in this case, for the mineral forms a solid mass, increasing in width as you descend from the surface, so that the supply seems to be practically illimitable. It is not only of value for the copper it contains, but it supplies the material for the immense sulphuric acid manufactories of Oker.

Pomaron and some other places in Spain and Portugal have similar massive deposits of this ore, which are quarried and sent to Newcastle in large quantities for the same purpose as mentioned in Article XI. of "Chemistry Applied to the Arts." The mines of Cobre, in the island of Cuba, are of a similar character; and those of Fahlun, in Sweden, also contain very large masses of this same ore, associated with other valuable minerals.

The oxides are commonly distinguished as the black and red oxides, and have the constitution of CuO and Cu_2O respectively. They rarely occur in large masses, but are generally more or less mixed with other ores; wherever they do occur, however, they greatly enhance their value, on account of the large relative proportion of metal which they contain, the theoretical per centages, according to the above formulæ, giving 79·8 of copper for the black, and 88·8 for the red oxide.

The carbonates, however, are to be had in much larger quantity, and they form a considerable proportion of the rich ores which are imported from abroad. In addition to the Siberian malachite, which has been already referred to as an ornamental article, the green carbonate of the chemical constitution, $CuCO_3CuH_2O_2$, was the prevailing ore in the celebrated Burra Burra mines of South Australia, from which nearly three-quarters of a million's worth of ore was raised in the first five years that the mine was worked. The same kind of ore is found in Western Africa and other parts in large quantities. It should contain theoretically 57·4 per cent. of metal. The blue carbonate, or azurite, contains a double portion of the $CuCO_3$, and yields, when pure, 55·2 per cent. of copper. It is, however, not so commonly diffused as the green variety.

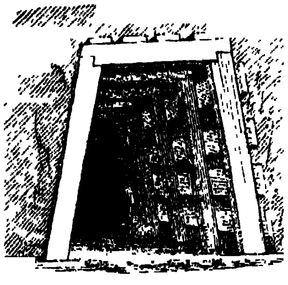
Fig. 14.—TIMBERS SUPPORTING WALLS OF LODE.

Copper also occurs sometimes in the metallic state, when it is called "native copper." The largest masses that have been known to exist have been found on the northern shore of Lake Superior: one of these masses is estimated to weigh 500 tons. The advantage of finding such riches as these is not, however, altogether without its drawbacks, as there is much difficulty in removing such huge pieces of metal. Of course, they are not unmixed with stones of quartz or other minerals, which render it difficult to reduce them to fragments by means of chisels, while on the other hand, the metal being tough in its nature, cannot be removed by blasting, as the ores can. The native copper, moreover, requires subsequent treating, as it contains other ingredients besides earthy matters, and not unfrequently other metals, which must be separated in order to produce a pure article.

The special instances which have been cited are sufficient to indicate the general abundance of copper ores in different parts of the world, but however rich they may be, they compete with difficulty with the comparatively poor ores of this country; and the question of supply is one much more nicely balanced than would appear at a cursory glance. Many of the Australian mines, for instance, including even the celebrated Burra-Burra, were closed on the rise in the price of labour when the gold discoveries in those colonies took place; a moderate advance in freights would render many other foreign mines no longer remunerative; while, on the other hand, there are many mines in Cornwall, now being carried on at a loss, which would yield a profit were only a slight advance in the copper standard to take place. Speculations, however, as to the probable course of prices in the future are worse than useless in respect of an article which can be supplied to a greater or less extent by almost every country on the face of the globe.

Let us turn to what has to be done to the ore on its arriving at "grass," or in other words, at the surface. Copper ore is not so intimately mixed with the gangue as tin, so that the pieces which are too poor to be worth smelting can readily be picked out. This is done by young girls at an almost nominal rate of wages, and the *deads*, as the waste is called, are thrown on one side. The larger lumps are broken up—*spalled* or *cobbed*—by women, lest there should be any valuable ore inside the mass, or to detach the ore from a superfluity of worthless stuff, or *dredge*. It is then picked over by the elder girls, who separate the ore, called *prills*, from the rest, and at the same time break up the mineral with a hammer of a particular form, termed a bucking-iron, until it is reduced to pieces not exceeding the size of a filbert nut. In some of the larger mines this is done by passing the prills between a pair of rollers revolving in opposite directions, and which are worked either by steam or water power. It is then *jigged* or *buddled* by being agitated under the surface of water, so that the smaller fragments of spar and other earthy material may be removed, and the ore, which is of greater specific gravity, remains behind in a clean state.

When a very large quantity of ore is raised it is found economical to lift the ore from the shaft to an elevated platform, and discharge it from the kibbles or boxes over a series of screens having the meshes of different widths, so that the ore may at once be separated into three sizes; the largest lumps which pass over the screens of four inches' mesh, are termed *rocks*, and have to be spalled; those which pass over the inch and a half screens are classed as *roughs*, and pass at once to the buckers, or if they are to be crushed by machinery, are only picked over first; the rest constitute the *smalls*, which are at once jigged under water on a sieve of one half-inch mesh, and those portions which do not pass through the sieve are added to the roughs previously described.

When the ores are dressed they are made up into piles, from which samples are taken and given to the representatives of each of the smelting works that they may make their assay preparatory to the ticketing day, the mode of sale of copper ore being similar to that of black tin. Each sample contains a pound and a half of ore. The processes required for a proper assay of copper ore are much more complicated than those of tin ore, for which reason fuller details must be given. The plan to be adopted depends materially upon the chemical constitution of the ore which has to be dealt with, and the proportion of foreign matter included in it. That the latter must exercise a considerable influence is sufficiently evidenced by the fact that the average samples of British ores only contain about eight per cent. of metallic copper.

The oxides and carbonates are most readily assayed; and more especially so when they contain no other foreign metal than iron. These are considered first-class ores. A certain quantity is finely pounded in a mortar, carefully weighed, and mixed with about three times its weight of a suitable flux. This mixture is put into a crucible, inserted in an ordinary assay furnace, and raised to a red heat. The crucible is left uncovered at first, and the door of the furnace is kept open until the contents of the crucible are fused, when they are both closed, and the damper drawn out so as to raise the furnace to its full heat. Within a quarter of an hour from this time the copper is reduced, when the crucible is withdrawn; and as soon as it has sufficiently cooled, the button of copper is taken out and weighed. If the ore be poor, it is desirable, after the first fusion, to add to the flux some sulphur and borax in equal proportions, to separate the regulus from the slag, and submit the former to a second fusion, until all the sulphurous acid is driven off. This gives a more accurate result than the single fusion, when there is a large proportion of earthy matter.

The common pyrites (cuproso-ferric sulphide) forms an ore of the second class. In treating this, the first object is to reduce the ore to a regulus, by fusing it with borax, which separates the earthy portions; and then to determine the amount of metallic copper in the regulus itself. This having been separated from the slag, is re-heated for the purpose of driving off all the sulphur, with which object it is at first only moderately heated in an open crucible, and kept stirred, so that all the contents of the crucible may be brought into contact with the air. After a sufficient quantity of oxygen has been absorbed to convert the copper into an oxide, the temperature is raised to drive off the remaining sulphur, and this is kept up until the whole of it is expelled. The oxide of copper thus obtained is lastly reduced to the metallic state, in the manner already described for the treatment of first-class ores.

The assayer has, however, very often to determine the value of samples that contain other metals besides those which have been already referred to. These mixed ores are generally ranked as third class. The principal ingredients against which he has to guard himself are arsenic and silenium. The powdered ore is first roasted in a furnace similar to that above named, for the purpose of driving off the greater part of the sulphur. This is then roasted a second time with a flux consisting of borax, lime, and fluor spar; and then again with bitartrate of potash, borax, and chloride of sodium, at a high temperature, until the reduction of the metal is complete. Before weighing the button the slag should be carefully pounded in a mortar, in case any metal should come away with it, and if it does not appear clean and bright, it should be re-melted with a little nitrate of potash.

During these several processes there is some slight loss of metal, which becomes a very appreciable amount in an ore of low percentage; but as a matter of practice the loss thus sustained is about equal to that which is unavoidable in smelting on a large scale, and the result obtained is a very safe criterion for the smelter. Assays taken by the wet way, as it is called by chemists, are far more exact, but they indicate a percentage of copper which can never be realised in any smelting works.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

V.—CLASSIFICATION OF EXHIBITS (*continued*).

We have next to consider in what order the various nations taking part in these exhibitions should be ranged. To avoid the invidious office of attempting to place the countries according to political precedence, an alphabetical order has hitherto been adopted *in theory*, while *in practice* the most powerful have, under diplomatic influence, generally managed to secure the foremost place. If, however, an attempt were made to range the contributing countries according to their geographical position, in relation to climatal influences on their produce and resulting trades, we should get at an approximation to a natural classification by taking Holland for a starting-point on the Continent, as having a climate of average character with our own country; then following the coast-line round to the Mediterranean, striking upwards to the north, and returning in zigzag order to the south, we should pass from Russia on to Asia, from thence to Africa, Australia, and America South and North. Some such scheme might be elaborated that should not offend the prejudices or susceptibilities of the truly great Powers. It is a question as to how the colonies of our own and other countries should be placed, so as best to show the civilising influences of parent races upon acquired territories. Thus, it has been usual to range the various colonies in alliance with countries from which they are offshoots. Thus the produce, etc., of Canada was allied to English exhibits, and so on; but might it not be better to connect it with America? We should then have under AMERICA—the United States, British America, and so on.

ORDER OF NATIONALITIES FOR SUB-DIVISION OF CLASSES.

GREAT BRITAIN.
HOLLAND.
BELGIUM.
FRANCE.
PORTUGAL.
SPAIN.
ITALY.
SWITZERLAND.
AUSTRIA.
GERMANY.
DENMARK.
NORWAY.
SWEDEN.
RUSSIA.
TURKEY.
ASIA MINOR.
PERSIA.
SIBERIA.

INDIA.
CEYLON.
CHINA.
JAPAN.
ETC.

MAROCCO.
ALGERIA.
TUNIS.
EGYPT.
NATAL.
CAPE COLONY.
ETC.

AUSTRALIA.
TASMANIA.
NEW ZEALAND.

BRAZILS, AND ALLIED S. AMERICAN CONTRIBUTORS.
BRITISH GUIANA.
DUTCH „
FRENCH „
ECUADOR.
COLUMBIA.
VENEZUELA.

WEST INDIES.

CENTRAL AMERICA.
MEXICO.
UNITED STATES.
ALASKA.
BRITISH AMERICA.

The idea of arranging the contributions to an international exhibition according to the scheme here defined seems, I find, to have originated with the Society of Arts, for at a special meeting of the Council held on Wednesday, the 14th of April, 1861, it was "Resolved—That the first of these exhibitions ought not to be a repetition of the Exhibition of 1851, which must be regarded as a special event, but should be an exhibition of works selected for excellence, illustrating especially the progress of industry and art, and arranged according to classes, and not countries."

In consequence, however, of the opposition expressed to this common-sense suggestion, by the representatives of influential Continental countries, this resolution was not carried out, and the system of courts and departments was again adopted in 1862; and at the Exhibition of 1871, neither one system nor the other was adopted, but a mixture of the old plan with the new ideas, which led to "confusion worse confounded." It is, however, to be hoped that in 1872 the system announced by the Commissioners for 1871 will be insisted on and carried out with firmness. It is a question whether this system might not in certain cases be modified at the discretion of the superintendents of classes and their committees of selection—viz., as to whether sub-divisions according to countries might not be applied with advantage to the groups constituting a class. Thus, in the class representing philosophical instruments, much valuable information might be obtained by bringing the telescopes, with the systems of mounting astronomical instruments in various countries, into one group, so as to facilitate direct comparison as to points of construction, price in relation to workmanship, etc.; so with microscopes, their accessories and methods of mounting objects; while, on the other hand, in the educational department, it would be better to let each country illustrate in the most complete manner attainable its special system of education, and appliances for teaching all branches of knowledge, whether adapted for the infant school or the college, and the scientific appliances of the educational department might form a connecting link with the class representing philosophical instruments, etc., of a higher order.

It is intended in future that the makers of certain *parts* of an article may become exhibitors: thus, a watch is made up of many parts, which are manufactured by distinct branches of the trade; so, workmen who make watch-springs, wheels, fusees, escapements, dial-plates, cases, and the numerous parts that make up the whole of which a watch is constituted, may display their skill independently of the "watchmaker" who puts together or sells the perfect instrument. So in the fine art department, "The artist may exhibit a vase for its beauty of painting, or form, or artistic invention, while a similar vase may appear in its appropriate place among manufactures on account of its cheapness or the novelty of its appearance," for "it is intended that these exhibitions shall furnish the opportunity of stimulating the revival of the application of the artist's talents, to give beauty and refinement to every description of object of utility, whether domestic or monumental."

Through the increase of objects that may by this rule be exhibited, the fear of overloading the galleries will be avoided by the judicious system adopted in 1871, of only admitting such articles as have passed under the supervision of a committee of selection for the group under which they are classified; and, further, by the equally judicious regulation that exhibitors will only be allowed "to send one specimen of each kind of object they manufacture," thus preventing a repetition of those shop-window-like displays of duplicate pairs of boots, shoes, pickle bottles, jam pots, mustard cans, etc., that certainly could only be regarded as good mediums for advertising and not of instruction.

Valuable space will likewise be saved by H.M. Commissioners providing the glass cases and stands necessary for the display of objects, and the appearance of the galleries greatly improved by the uniformity of aspect and design. The same applies to the supply of motive power for machinery, etc., or the use of gas, fire, steam, or water.

The method of making the exhibitors supply the necessary matter for the catalogues, and the catalogues in turn furnishing the materials for the labels to be attached to each article exhibited, is a novel principle that strongly recommends itself to those who have the systematising of public museums, etc.

In the forms sent to manufacturers invited to contribute to the Exhibition of 1871, will be found the following regulation:—

> XII. To every object, when exhibited, will be attached a label, prepared by Her Majesty's Commissioners, which will contain the following particulars:—
>
> 1. The name of the object.
> 2. The exhibitor's name.
> 3. His address.
> 4. The name of the designer or actual maker (*if the exhibitor pleases*).

5. The reasons why it is exhibited, such as its
   - Novelty,
   - Design,
   - Excellence,
   - Cheapness.
6. The price.
7. Any explanations, such as the materials of which it is composed. The purpose for which it is intended.

It will be found, however, that in practice the details were confined to the name of object, price (when given by the exhibitor), and the exhibitor's name, which, as a rule, would be found sufficient, if supplemented in the catalogue by an index of contributors, with their addresses and record of honours acquired at previous exhibitions, and the biographical notices of all artists and producers announced in the preface to the catalogue of the Exhibition of 1871. Thus, if Professor L. Knaus contributed many pictures, and they were *distributed*, it will be seen by the annexed example that *the repetition* of the bibliographical matter would add materially to the bulk of the catalogue, when such a system was applied to other exhibitors.

7. A SHOEMAKER'S WIFE, WITH HER CHILD AND AN APPRENTICE, WATCHING A MOUSE IN A TRAP ... ... *Prof. L. KNAUS.* GERMANY. 140, *Duisburger Strasse, Dusseldorf.* Born at Wiesbaden; pupil of the Dusseldorf School of Art; Member of the Bavarian Order of Maximilian; Officer of the Legion of Honour; Knight of the Order of the Red Eagle, 3rd Class; Knight of the Order of Francis Joseph; Knight of the Order of Leopold; Knight of the Order of Adolphus of Nassau; Member of the Academies of Berlin, Vienna, Stockholm, Amsterdam, Munich, Antwerp, Brussels. First Class medal, 1855; Grand Prize, 1867.*

But if such details were given in the INDEX, once would suffice for all, and the information would be useful to the public and the exhibitor alike. Thus—

INDEX.

Name.	*Biographical Notice.*	*Number.*
BONHEUR, Mdlle. MARIE ROSA	FRANCE. *By, Commune de Thomery, Seine-et-Marne.* Born at Bordeaux; pupil of R. Bonheur, her father: First Class Medal, 1855; Chevalière of the Legion of Honour, 1865; Second Prize, 1867.	1141, 1142, 1326, 1327

While in the BODY OF THE CATALOGUE this artist's works would stand thus:—

EAST GALLERIES (ROOMS XIX. AND XX.), FRANCE.

Name.	*Subject.*	*Contributor.*
1141 BONHEUR, MARIE ROSA	"Returning from the Mill."	*Mr. F. T. Turner.*
1142 BONHEUR, MARIE ROSA.	"Forest of Fontainebleau."	*Mr. F. T. Turner.*

* * * * * * *

Name.	*Subject.*	*Contributor.*
1326 BONHEUR, M. ROSA.	"A Family of Deer."	*Mr. H. F. W Bolckow, M.P.*
1337 BONHEUR, M. ROSA.	"Sheep"	*Baronne d'Erlanger.*

As a sample of the labels prepared from such a catalogue the annexed may be given, with the statement that the labels indicate by coloured borders the country from which the object comes. Thus the border for Austria is *orange;* Belgium, *dark blue;* China and Japan, *magenta;* Denmark, *chocolate;* France, *green;* German Empire, *black;* Greece, *full brown;* Italy, *pearl grey;* Netherlands, *brown;* Norway and Sweden, *light blue;* Russia, *pale grey;* Spain, *lemon;* Switzerland, *grey;* Tunis, *fawn;* Turkey, *lavender;* United States, *blue;* United Kingdom, India, and Colonies, *red.*

CLASS X.

6696 COLLECTION OF GEOMETRICAL MODELS, PRICE £7. *J. Schröder.*

GERMAN EMPIRE.

Much discussion and ill feeling has arisen on the part of English exhibitors as to allowing the annexes attached to certain foreign countries to be used as mere bazaars, not merely for their manufactures admitted to the several classes, under the approval of the committee of selection, but for the sale of goods generally, a privilege not accorded to or desired by English contributors, who feel aggrieved at an undue advantage being accorded to foreign traders, whose home ideas are of a conservative character—a privilege not discovered till after the exhibition had been open some months. It is stated in reply to this charge, that when the representatives of the French manufacturers were informed that the custom of giving prize medals was to be discontinued, they declared that if they were expected to exhibit "*without profit or glory*" they must decline to enter the field; so, as a sop in the pan, the permission to sell in the annexes was accorded. All attempts to turn international exhibitions into bazaars for open touting or selling ought to be discouraged to the utmost; but there can be no objection to the appointment of official agents for the several classes, under such regulations that the interests of both English and foreign exhibitors shall be fairly provided for, and the convenience of the public considered. Country and foreign visitors, with little time at their disposal, would fully appreciate the advantage of being able to visit an office within the building, where they could give their commissions for objects only obtainable at the close of an exhibition, or to secure duplicates of such as could be supplied at an earlier date. So far for the question of "profit;" for undoubtedly the object of these displays is to encourage progress in manufactures and art.

As to the question of "glory," or the honours to be acquired by exhibitors, the resolve on the part of H.M. Commissioners to dispense with the award of prizes, shelves a difficulty that has been fully discussed; but if the distinction of admission is to be regarded as an honour of equivalent value, would it not be policy to give the promised CERTIFICATE in the form of a bronze *medal*,* to which a conventional value is attached that never pertains to lithographic documents. The issue of special untransferable personal season tickets to the exhibitors can only be regarded as a decision founded on sound policy, for it is only fair that those who contribute to a feast should find a place thereat, without being charged for the privilege by those who preside at it, as was the case on former occasions. Moreover, it is only right that exhibitors should have the opportunity of seeing that the articles which they exhibit are kept properly displayed, and in good order, without being fined in the shape of charges for admission, for by the constant vibration articles often get shaken into positions ill suited for their proper display, or get dimmed by greater or less deposits of dust, which is almost sure, in the course of time, to find its way into cases, even of the best make.

In connection with the question of dust, displacement, and re-arrangement, I would point out the necessity for the superintendents of classes or their assistants being present to meet exhibitors at set times and days, if the Commissioners undertake the entire charge or keeping of the exhibits, as introduced in 1871. In many cases I saw labels in positions where they could not be read, and trays, etc., placed one over the other, in a provisional manner, consequent upon the hurry to get things into place for the opening, that were never put right during the entire term of the exhibition—matters that would have been immediately corrected had provision been made for superintendents and exhibitors coming into periodical contact. In the Fine Arts Gallery a life-sized picture of a female in the costume of Eve *before* the fall, through a blunder in the numbering, was described in the catalogue as a "*Portrait of the Artist,*" much to the horror of many maiden ladies, who could hardly believe it possible that things had come to such a pass with the order of strong-minded women, that any member of the Bohemian sisterhood could *coolly* depict herself while "holding, as it were, the mirror up to Nature," and then having the production thus catalogued. The mystery would have been sooner solved had artist and superintendent come into contact, for it ultimately proved that the proper designation of this subject was "*Truth*" (the *bare* truth it may be assumed), and the artist of the masculine gender.

The same rule holds good in regard to the "Committee of Selection," as, to my personal knowledge, many objects tendered for admission were rejected, which would have been (and were ultimately) admitted, had an opportunity been afforded for exhibitor and committee coming into contact, for it frequently happens that experts *do not intuitively* recognise novel points of construction, ingenuity of arrangement, or the value of cheaper processes for producing known results, till a personal explanation or demonstration has been given; and it is but human nature to assume airs of infallible perception when placed in positions to dictate *ex cathedrâ.*

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* See "Announcement of the Forthcoming Series of Annual International Exhibitions," etc., Offices of H.M. Commissioners, 1870.

* As yet (January, 1872) the certificates for 1871 have not been distributed to the exhibitors, so that their form is at present unknown.

Official reports on exhibitions are valuable alike to exhibitors and the public, if written by those completely conversant with the range of subjects they undertake to report on. When there is a sub-division of labour, there should be a clear understanding between the staff of reporters, as to the ground each intends to occupy; for in some of the reports for 1871 I notice that, while some attempt to pass judgment upon subjects with which they are evidently unfamiliar, though conversant with the details of other groups, others, through want of preconcerted arrangements, clash with the ground covered by reporters on allied groups. Such matters of detail ought to be arranged on a satisfactory basis for future exhibitions.

CHEMISTRY APPLIED TO THE ARTS.—XVI.

BY GEORGE [illegible], F.C.S.

ALCOHOL AND ETHERS.

It is not intended in this article to treat of the manufacture of the various spirits having alcohol for their basis which are simply used as exhilarating drinks, amongst which brandy, gin, rum, whisky, etc., are the most familiar preparations—but rather to speak of alcohol in its more innocent, nay, useful applications.

Absolute alcohol is a compound of carbon, hydrogen, and oxygen, in certain definite proportions, the most familiar being what chemists would distinguish as ethylic alcohol, or hydrate of ethyl, C_2H_6O. Another alcohol, of not uncommon occurrence in the arts (as it is much cheaper than the preceding, being free of duty), is that derived from methyl, CH_3, having the formula CH_4O; and a third, the amylic, $C_5H_{12}O$. It will be seen, in comparing these three formulæ, that they bear a definite relation to one another—beginning with the hydrate of methyl as the lowest in the series, the higher terms increase by the addition of two atoms of hydrogen to each one of carbon. It is unnecessary to give the intermediate and higher terms, of which there is a long series, as those above-named are the most important. It is worthy of remark that each of the alcohols may be converted into an acid by the replacement of two atoms of hydrogen by one of oxygen; C_2H_6O becoming in that case acetic acid, $C_2H_4O_2$, as described in the last article; the hydrate of methyl becoming formic acid, CH_2O_2, and that of amyl becoming valerianic acid, $C_5H_{10}O_2$, and so on throughout the whole series.

The sweet vegetable juices or extracts are liable to undergo fermentation, and it is well known that powerful and exhilarating liquors are derived from them. They all contain alcohol to a greater or less extent, to which ingredient these special characteristics are due. The juice of the grape was perhaps the first source of alcohol, and so it obtained in this country and some others the name "spirit of wine." It is now however very largely manufactured from a great variety of substances, the material from which it is made often imparting to it a peculiar smell or flavour, which has led to a specific name being given to such spirit. Thus, the juice of the sugar-cane produces rum; rice, arrack; etc. Malt made from any kind of corn will yield a spirit, and on the Continent of Europe potatoes, mangold, beetroot, carrots, and many other roots of a similar character containing saccharine matter, are mashed up and fermented to make brandy or other spirituous liquors.

The character of the transformation will be best understood by comparing the chemical constitution of the substances. Grape sugar (or glucose, which is the scientific term) consists of $C_6H_{12}O_6$ when all the water which is usually in combination with it is driven off, and under the action of the vinous fermentation it separates into two portions; the result is the formation of two atoms of alcohol, $2C_2H_6O$, and two atoms of carbonic anhydride, $2CO_2$, which will be found to make up exactly the formula of the original grape sugar.

Alcohol has such an affinity for water, that it is extremely difficult to keep it absolutely pure, even after it has once been made so. We will suppose that the distiller has produced the raw spirit, which, when duly doctored, may constitute either gin or brandy; it will be found on examination to consist of $C_2H_6O +$ an indefinite quantity of water. To render it absolute, it is usually distilled over and over again several times, by which means it increases in strength each time; but this process alone will not thoroughly effect the separation of all the water, however often it may be repeated. About 9 per cent. of water is found still to remain mixed with the spirit after carrying fractional distillation as far as possible. The final process is therefore varied, and the last distillations are made in the presence of some carbonate of potassium or chloride or hydrate of calcium, which, having a greater affinity for water than even the alcohol itself, takes up the moisture and only allows the anhydrous spirit to pass over from the retort. If quicklime be used, the retort should be about two-thirds filled with it, and then sufficient alcohol poured in to cover it over; the lime will soon become slaked by the absorption of the water contained in the alcohol, which can then be separated by distillation. This is repeated several times, until all the water is removed; and the alcohol, being thus rendered absolute, must be carefully preserved from contact with the air, or fresh moisture will be absorbed.

As alcohol is considerably lighter than water, the purity of it can be tested with great accuracy by ascertaining its specific gravity. The pure spirit will not exceed 0·795 at the ordinary temperature of the air. Tables have been constructed showing at a glance the relation of the specific gravity to the percentage of alcohol at given temperatures, so that all that need be done is to ascertain these data as to any specimen in question, and the strength of the spirit will be known at once.

Another mode of determining the same point is by the use of the hydrometer, that of Sykes' being the one approved by our Government, and generally used in calculations for the Revenue. Proof spirit, as it is called, is the standard for the assessment of duty; and is of such a strength that its weight shall be 12-13ths of that of water at a temperature of 51° Fahrenheit. Taking, therefore, this as the basis, the hydrometer is so constructed that by the addition of weights to the portion below the bulb it shall just float in the spirit, the part above the bulb being graduated so that any one can read off to a nicety the precise point of immersion; and then, by reference to the calculated tables, the exact strength of the spirit above or underproof is at once ascertained. Thus, at a temperature of 60° the specific gravity of proof spirit is 0 9186; and the relative proportions by weight of alcohol and water will be found to be 49·5 of the former to 50·5 of the latter.

A third mode of determining the strength is by ascertaining the boiling point, which naturally becomes more and more assimilated to that of water, 212°, as the quantity of this ingredient augments, the boiling point of pure alcohol being very much lower. The following table will show the effect of a reduction in the strength of the spirit in this respect:—

Percentage of Alcohol.	Boiling point, Fahrenheit.
90	174·2°
80	175·3°
70	177·6°
60	179·4°
50	181·6°
40	183·4°
30	187·2°
20	192·4°
10	199·2°

It will readily be inferred that these tests are only applicable to such spirits as contain no other ingredient; for instance, those which are sweetened will have a greater specific gravity, dependent upon the amount of saccharine matter held in solution, and the boiling point will also vary according to the nature and proportion of the other ingredients.

Pure alcohol exercises many important functions in chemistry. By mixing it with snow an intense cold can be produced; and it is almost impossible to freeze it, as it may be reduced to 150° below zero without congelation, on which account it is used in the manufacture of thermometers which may be required to register very low temperatures. When diluted with water it is a powerful stimulant; but strong alcohol is highly injurious to the animal system, as it withdraws the water necessary to the healthy condition of the tissues, and coagulates the albuminous portions. It is an excellent solvent for all kinds of resins, fats, and essential oils, and as such is used in the preparation of the best varnishes, soaps, and perfumes. Reference has already been made to this use of it in Article VIII. Many other substances are also soluble in alcohol, which are not at all affected by water. It is likewise used in the preparation of many compounds which are of much value in medicine, especially of the various anæsthetics, which are now so extensively employed.

Chloroform, for instance, is yielded by the distillation of alcohol along with some chloride of calcium. The proportions required are 6 parts of the latter to 1 of alcohol containing 84 per cent. of spirit, and 30 parts of water; or it may be made from 8 parts of the chloride of lime, 1 of quicklime, 1 of alcohol, and 40 of water, which will yield a quantity of rectified chloroform equal to one-third of the alcohol consumed. The resulting liquid will have the constitution $CHCl_3$, the effect of which in producing insensibility to pain on being inhaled is well known. For this purpose it is of the utmost importance that it should be as pure as possible, especially as the ingredients most likely to find their way into it are not easily detected, except by the injurious effects they produce upon the individual. It is a highly volatile liquid, though at the same time a very heavy one, having a specific gravity of 1·49 at 60°. This circumstance affords a ready means of detecting any adulteration, either with alcohol or ether, in both of which it is soluble; in such case the weight of the liquid would be greatly reduced, as there is such a wide difference between their specific gravities and that of chloroform. It possesses in a very high degree the power of preserving animal matter from putrefaction.

Chloral, the hydrate of which has recently been introduced as a medicine, and is now very generally administered for the purpose of inducing sleep, is another product of alcohol and chlorine. The most direct process for its preparation is to pass dry chlorine gas into absolute alcohol. It is of the greatest importance that both of the ingredients shall be free from admixture with water, and as each has a great affinity for it, much care must be taken in order to ensure its absence. The gas is best dried by passing it through some strong sulphuric acid, or over chloride of calcium. At the commencement of the operation the alcohol must be kept cool, by exposing the outside of the glass vessel which contains it to the action of cold water, so as to prevent the contents from taking fire; but as the absorption of the chlorine increases, the mixture must be heated nearly to the boiling point. It ultimately becomes thick and syrupy; and after standing a while it solidifies into a soft crystalline mass, which is the hydrate of chloral. This substance is then melted, and agitated with four to six times its bulk of sulphuric acid, when the pure chloral will separate and float on the top. It is finally distilled over slaked lime, for the purpose of removing any hydrochloric acid which may have been formed in the course of the operation. Pure chloral is a thin, pungent, colourless oil, of a specific gravity of 1·5, which boils at 203° Fahrenheit.

Alcohol is also the foundation of all the different kinds of ether which are used in pharmacy or otherwise. The description in most common use is often called sulphuric ether, because the acid bearing that name is used in its manufacture; but it is a very misleading title, as there is no sulphur whatever in its composition. The oxide of ethyl is the scientific name, as it consists of $2C_2H_5\,O$. The reason for adopting this name will appear more plainly presently, when other ethers come to be considered, as it will then be seen that the one atom of oxygen is capable of being replaced by other elements or combinations, and that the $2C_2H_5$ represents ethyl itself, a gaseous substance, which on burning yields a brilliant light.

There are some general characteristics common to all this series of products. They are highly volatile inflammable liquids, of a very light specific gravity, with a fragrant odour, and having the faculty of producing numbness even to complete insensibility when inhaled in considerable quantity. They will mix with alcohol in any proportion, but not with water, except to a very slight extent. They are valuable as solvents, most of the articles soluble in alcohol being also capable of being dissolved by ether, and in some cases more readily than in the former.

The ordinary plan of making the oxide is to distil over a mixture of sulphuric acid and alcohol. If the relative proportions are as two to one, the mixture will boil at about 250° Fahrenheit, gradually rising to 280°, and the vapour when condensed will be found to consist of a mixture of ether and alcohol, the ether greatly predominating as it reaches the higher temperature; as the boiling point rises from that to 320°, ether will come over mixed more or less with water; and if the distillation be carried beyond that stage the boiling point will rise still higher, but the contents of the still will be converted into olefiant gas and sulphurous acid. The object of the manufacturer is therefore to keep the boiling point at about 300°, which is done by constantly keeping up the supply of alcohol, so that the relative proportions may not materially vary.

Hydrochloric ether, or more exactly chloride of ethyl, C_2H_5Cl, may be made either by saturating absolute alcohol with hydrochloric acid gas, or by distilling alcohol with one of the chlorides, such as common salt. It is used in medicine generally in combination with alcohol.

Nitric ether, $C_2H_5NO_3$, is also used for a similar purpose to a considerable extent.

SEATS OF INDUSTRY.—XXIV.

ST. LOUIS.

BY WILLIAM WATT WEBSTER.

In 1762 M. d'Abbadie, the Director-General of Louisiana, granted to a company of merchants, of whom Pierre Liqueste Laclede was the leader, the exclusive privilege of trading with the Indians on the river Mississippi, along with permission to settle on any spot in the valley of the "Great Waters" they might choose to select. The qualities desiderated in a site by these pioneers of commerce were facilities for carrying on the fur trade, and natural strength of position for defence against the Indians. It was because it possessed both of these advantages in a high degree that Laclede and his companions, after a careful exploration of the territory, established themselves, on the 15th of February, 1764, at the place afterwards occupied by the important commercial city of St. Louis. To the trappers the confluence of the different rivers in the immediate neighbourhood was a great attraction, as it afforded a comparatively easy means of communication with the great hunting-fields. At first but four houses were built, and the settlers were proportionately few. On the 11th of August, 1768, a Spanish officer, named Rious, with a company of Spanish troops, took possession of Laclede's settlement and Upper Louisiana, as the district was then termed, in the name of the king of Spain, under whom it remained until 1801, when it was restored to France. It was sold to the United States in 1803. By 1770 the number of settlers at St. Louis had increased to forty families, and a small garrison was stationed there for its protection. In common with other settlements on the Mississippi, Illinois, and Wabash rivers, St. Louis was threatened with destruction in 1780 by a British force, but this disaster was averted through the energy of General George Rogers Clark. Some statistics of the fur trade of St. Louis for the fifteen years immediately preceding 1804 have been preserved, which show that at that early date it had reached considerable dimensions. The average annual value of the furs collected at the port during that period amounted to 203,750 dollars, and the number of skins were—150,000 deer skins, 36,900 beaver skins, 8,000 otter skins, 5,100 bear skins, and 850 buffalo skins. In 1804 the population was estimated at between 1,500 and 2,000 persons, one-half of whom were absent during the greater part of the year on hunting expeditions, either as trappers or as voyageurs—the latter name being given to the boatmen who brought home the skins. In 1813 the first brick house was erected; and in 1817 the first steamboat arrived at the port.

St. Louis made little progress in population during the first two decades of the century, its inhabitants only numbering 4,598 in 1820; but two years later it was chartered as a city under the title conferred on it by Laclede, in honour of Louis XV. of France. About the year 1825 the growth of Illinois became marked, and between that year and 1830 St. Louis received considerable additions to its population from that State. It was at this period that the foundation of the trade between Illinois and St. Louis was laid—a connection that has contributed largely to the prosperity of the latter, and that still constitutes an important branch of the commerce of the port.

By 1829 the keel boats had entirely disappeared from the river; and a steamer, named the *Yellow Stone*, ascended to the Great Falls about the same date. During the ten years between 1820 and 1830, however, but little increase took place in the population, which in the latter year only numbered 6,694; but in the succeeding decade it was much more than doubled, having in 1840 reached 16,469. It was then that the extraordinary rapidity of growth that has distinguished the city, even among American towns, first distinctly showed itself. About this time extensive warehouses began to be erected near the brink of the river, which is the oldest part of the city, and is still the centre of its commerce. Up till the year 1849 a large proportion of the houses in St. Louis were built of wood; but at that date a great fire occurred, that destroyed a considerable part of the city, and the new houses erected were chiefly constructed of a limestone found in the neighbourhood, which, though soft when first taken from the quarries, becomes hard and durable after it has been exposed for some time to the action of the atmosphere. The returns of the population for 1850 showed that St. Louis contained 75,204 free citizens and 2,650 slaves, making a total of 77,850, or nearly five times as many inhabitants as in 1840. Of these the larger half, or 40,414, were natives of foreign countries; 23,774 having been born in Germany, 11,257 in Ireland, 2,933 in England, and 2,450 in other foreign countries. The natives of the United States resident in the town at that date numbered 37,436. During the succeeding two years the population of the city and suburbs was found, by a local census that was taken in 1852, to have increased by about 20,000.

For some time previous to the date last mentioned St. Louis had been the principal emporium of the countries on the Missouri and the Upper Mississippi. The value of the produce brought to the quays of the city in 1849 was estimated at considerably more than 10,000,000 dollars; and at the same date the shipping belonging to the port, consisting mostly of steamers, reached an aggregate of 32,225 tons. Three years later the quantity of flour annually ground and dressed at the extensive mills in the city and its vicinity amounted to 393,184 barrels; and it was estimated that the flour-mill machinery was capable of producing 3,000 barrels per diem. In 1852 no fewer than 3,184 steamers arrived in the port; and, according to the customs returns, 37,861 tons of shipping, of which 32,646 tons represented steam-vessels, were owned in St. Louis. The official statistics for 1855 give the number of the inhabitants of the city proper in that year as 97,642, of whom 94,686 were free; and it is estimated that the entire population of St. Louis and its suburbs at this date amounted to nearly 120,000. Two items from the trade returns for 1859 will serve to some extent to show the nature and dimensions of the commerce of the city at that date. The produce of the flour-mills during that year amounted to 873,506 barrels, or nearly three times the quantity turned out only seven years before. In the same year there were received into St. Louis 53,174 hogsheads, 9,186 barrels, and 6,693 boxes of sugar. The value of the furs brought to the port in the following year was estimated at 549,422 dollars, of which amount 340,000 dollars represented buffalo skins, 85,000 having passed through the market. By 1852 lard and linseed oil had become important items in the produce of St. Louis, 5,000 barrels of the former having been exported in that year. In 1860, however, no less than 30,000 barrels of lard were manufactured, and the number of hogs slaughtered in St. Louis alone in that year was calculated at 78,000. The packing and shipping of pork, beef, and hams had also by this time become a very extensive branch of trade, and employed a large amount of capital and a large number of persons. Tobacco manufacture was then also carried on in the city on an extensive scale by about a dozen establishments.

But the manufacture of iron surpassed and still surpasses all the other industries of St. Louis, both as regards the amount of capital invested and the number of persons employed in it. The district surrounding St. Louis is remarkably rich in mineral resources, comprising iron, coal, lead, copper, and marble, and its mineral wealth has constituted an important element in its prosperity. Among the most striking natural objects in the State of Missouri, of which St. Louis is the principal city, although not the capital, are its two hills, composed of micaceous oxide of iron, situated in St. François county. One of these hills, called "Iron Mountain," rises 350 feet above the plain, and is one mile and a half broad at its summit; the other, called "Pilot Knob," is one mile and a half in circuit at the base, and 308 feet high. Vast quantities of the ore from these mountains are brought to St. Louis, and there smelted, and manufactured into stoves, railway machinery, and locomotive and stationary engines. In 1858, 17,565 tons of pig iron from Iron Mountain and Pilot Knob were landed at the port; in 1859 the quantity rose to 16,250 tons; and in 1860 to 19,700. About 50,000 tons of iron from other points were at that time annually worked up at St. Louis. The shipping owned, enrolled, and licenced at the port in 1860 amounted to 64,683 tons; and the number of steam-vessels that arrived at St. Louis in that year numbered 4,371, representing a total burden of 1,120,039 tons. During the year 1860 nearly 2,800 buildings were erected in the city, at a cost of about 7,500,000 dollars, and at that date the population amounted to 151,780, of whom about 1,500 were slaves. There were then fifty-three periodicals and newspapers published in St. Louis, including eleven daily newspapers, issuing weekly editions; three tri-weeklies, twenty-four weeklies, four semi-monthly publications, and two quarterlies. At the present time the population of St. Louis, notwithstanding the losses of men and money in the Civil War, is calculated at about 200,000.

St. Louis is admirably situated on an elevation, consisting of two plateaux of limestone formation, the one about fifty feet above the floods of the Mississippi, and the other about sixty feet. It is about eighteen miles below the mouth of the Missouri, and nearly 200 miles above the mouth of the Ohio. By the river the distance between St. Louis and New Orleans—to which the navigation is always open—is a little over 1,200 miles. It is the capital of the judicial district and county of St. Louis, and is governed by a mayor and a common council, consisting of twenty members in addition to the mayor. The city covers an area of about sixteen square miles, but the thickly-populated part is only from two to two and a half miles in length, following the course of the river, and about one and a quarter miles in breadth. Portions of the town, however, extend nearly seven miles along the Mississippi, and nearly three miles from its right bank. The Upper Mississippi, the Ohio, the Missouri, and their numerous tributaries, afford connected and easy water communication, extending to about 8,000 miles, between St. Louis and vast regions extraordinarily rich in mineral, vegetable, and animal products. It is the principal seat of the American fur trade, and of the overland trade with Mexico. St. Louis is remarkably well built, the streets, for the most part, being sixty feet wide, and, with few exceptions, intersecting each other at right angles. Front or Levee Street, which runs along the river, is upwards of 100 feet wide; and the side next the Mississippi is occupied with a range of massive stone warehouses of imposing appearance. Among the public buildings in the city the most noteworthy are the City Hall; the Court-house, erected at an expense of half a million of dollars; the new Custom House and Post-office, which cost 350,000 dollars; and the central market buildings, which occupy the site of the old market and town-house. There are about eighty churches in St. Louis—the Methodists and the Roman Catholics being the largest denominations, and having each about an equal number of places of worship. The Roman Catholic cathedral, built in 1831, is a very handsome Doric structure, with a tower ninety feet high, surmounted by a spire. The Roman Catholics have also a university in St. Louis, called the St. Louis University, which was founded by the Jesuits in 1818 for the study of the classics and *belles lettres*: it has also a medical faculty. Between 100 and 150 students attend its classes. In the Washington University at St. Louis, incorporated in 1853, all the branches of study commonly included in a university curriculum, with the exception of theology, are taught. A German institute of science was founded in 1856. There are also in the city other colleges and schools for the higher class of education.

PRINCIPLES OF DESIGN.--XXVIII.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

HARDWARE.

Having considered metal work in its more costly branches, we come to the consideration of hardware; and I am glad that we have reached that part of our subject which deals with inexpensive materials, for they are those which must be generally employed, while works formed of the precious metals can be used only by comparatively few persons. The object of art is the giving of pleasure; the work of the artist is that of giving ennobling pleasure. If as an artist I give pleasure, I to an extent fulfil my mission; but I do so perfectly only when I give the greatest amount of the most refined pleasure by my art that it is possible for me to give. If by producing works which can be procured by many I give pleasure, it is well that I do so; but if the many fail to derive pleasure from my works, then I must address myself to the few, and be content with my lesser mission. Education appears to be necessary to the appreciation of all art; the artist, then, is a man who appeals to the educated. If some persons, by their superior education, are enabled to appreciate art much more fully than those who are more ignorant, and can consequently derive much more pleasure from it than the less cultured person, it might then be desirable that the artist should address himself, through costly materials, to the few, for thereby he might be giving the greatest amount of pleasure. I always, however, like to produce works in cheap materials, for then I know that I form what is capable of giving pleasure to the poor man—if appreciative—who may possess it, as well as the rich.

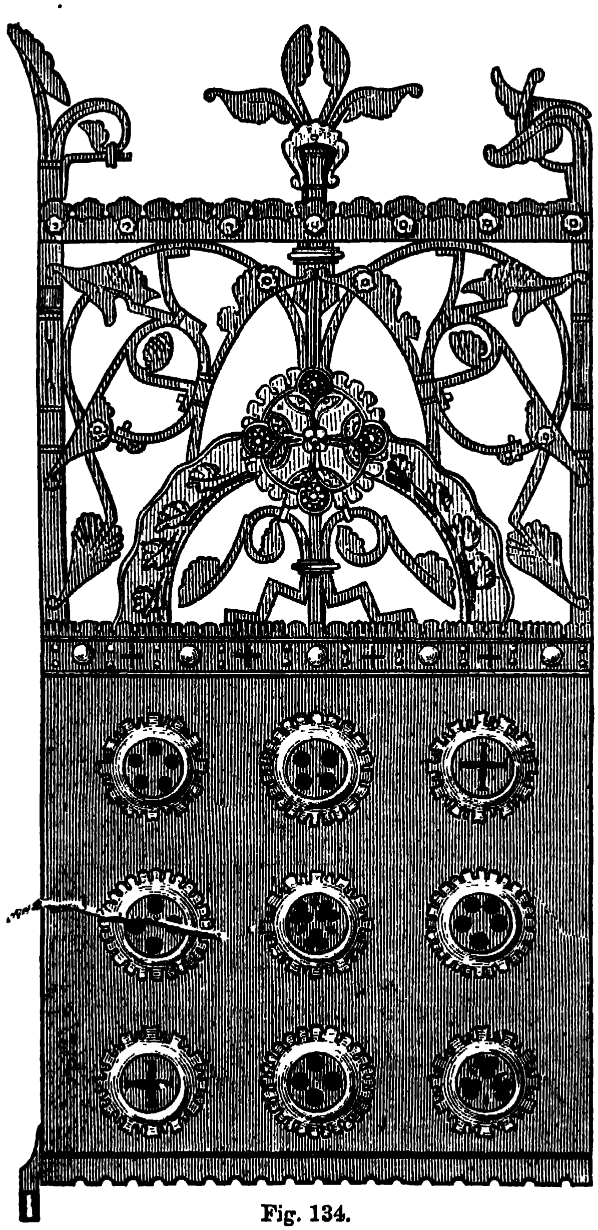

Fig. 134.

In hardware we have two classes of work produced which appear to have little in common—the one class being characterised by a preponderance of excellence, and the other by the dominance of what is coarse and inartistic. The first class of work is that which is produced by what are termed ecclesiastical metal workers; the second consists of what is generally known as Birmingham ware.

It is an error to suppose that these so-called ecclesiastical—or mediæval, as they are sometimes called — metal workers produce only ecclesiastical and mediæval work. On the contrary, some of these men—and they are now many in number — devote themselves almost exclusively to domestic work, and most of them fabricate articles in all styles of art. If I wanted an artistic set of fire-irons, I should go to one of the ecclesiastical warehouses, for there I have seen many sets that my reason commends and my judgment approves; but I never saw a set produced for the general market that I liked; and the most artistic fenders, grates, and gas-fittings, in almost any style, are to be got at these shops. I do not mean to convey the impression that all things made at these ecclesiastical warehouses are good, and that all things of Birmingham (or Sheffield) manufacture are bad, for I have seen indifferent works in these mediæval shops, and I have seen excellent things from Birmingham—especially I might mention as good certain gaseliers produced by two Birmingham houses—but as a rule the works found in the mediæval warehouses are good, and as a rule the works in hardware produced by Birmingham and Sheffield are bad, in point of art.

It will appear monotonous if I insist that the materials of which works of hardware are formed be used in the easiest manner in which they can be worked, and that every article be so formed as perfectly to answer the end of its formation. Yet I must do so. Let us look for a common set of fire-irons, and we shall find that nine pokers out of ten have a handle terminating in a pointed knob. Now, as the object of this knob is that of enabling us to exercise force wherewith to break large pieces of coal, the folly of terminating this knob with a point is obvious. A poker is, essentially, an object of utility; it should therefore be useful. It is ridiculous to talk of a poker as an ornament; yet we find it fashionable now to have a bright poker as an ornament, which is obtrusively displayed to the visitor, and a little black poker, which is carefully concealed from view, reserved for use. I cannot imagine what people will not do for show and fashion, but to the thinking mind such littleness as that which induces women to keep a poker as an ornament must be distressing; and until persons who desire to be regarded as educated learn to discriminate between an ornament and an article of utility little progress in art can be made. If a poker is simply a thing to be looked at, then it may be as inconvenient as you please, for if it has no purpose to fulfil by its creation it cannot be unfitted to its purpose. The same remark will apply to shovel and tongs. If they are intended as works of utility, then their form must be carefully considered; but if they are to be mere ornaments I have nothing to say respecting them.

Utility and beauty are not inseparable; but if an article of any kind is intended to answer any particular end, it should be fitted to answer the end proposed by its formation; but after it is created as a work of utility, care must be exercised in order that it be also a work of beauty. With due consideration, almost every work may be rendered both useful and beautiful, and it must ever be the aim of the intelligent ornamentist to render them so.

Iron is capable of being wrought in various ways; it may be "cast" or "hammered," or cut or filed. "Casting" is the least artistic mode of treating iron; but if iron is to be cast, the patterns formed should be so fully adapted to this mode of formation that the method of working may be readily apparent. It is foolish to seek to make cast-iron appear as wrought-iron: cast-iron should appear as cast-iron, and wrought-iron as wrought-iron. Cast-iron is brittle, and must not be relied upon as of great strength; while wrought-iron is tough, and will bend under great pressure rather than break. Wrought-iron can be readily bent into scrolls, or the end of a rod of metal can be hammered flat and shaped into the form of a leaf, and parts can either be welded together or fastened by small collars, pins, or screws. One or two illustrations of good wrought-iron work by Skidmore, Benham, and Hart, we give in our engravings.

As an illustration of a simple railing, we figure one shown in the International Exhibition of 1862 (Fig. 138), which is in every respect excellent. Its strength is very great, yet it is quaint and beautiful. As it was shown it was coloured, and the colour was so applied as to increase its effect and beauty. If the student will carefully devote himself to the consideration of

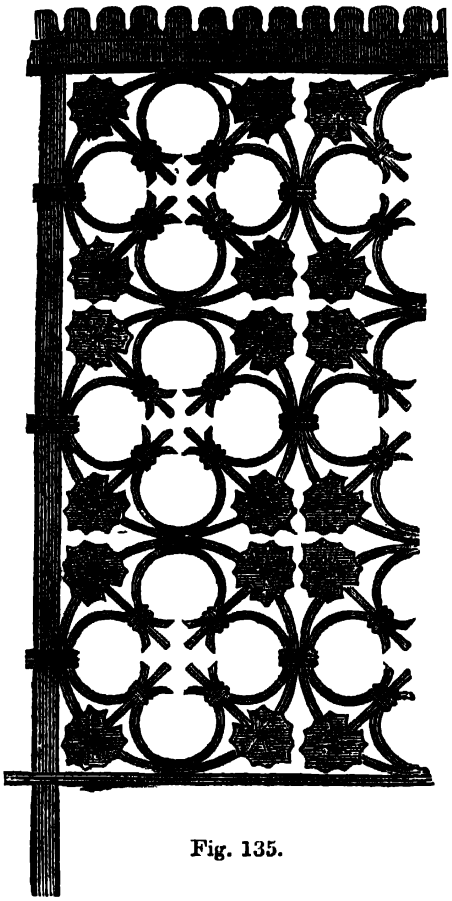

Fig. 135.

excellent works in metal, he will learn more than by much reading. Let him procure, if possible, the illustrated catalogues of such men as Hart of London, Hardman of Birmingham, and Dovey of Manchester, and study the sketches which he will there see, and he will certainly discover the principles of a true art, such as he must seek to apply in a manner concordant with his own original feelings.

Of our illustrations, the example by Skidmore (Fig. 137) furnishes us with an excellent mode of treatment. Iron bands are readily bent into volutes, or curves of various descriptions, and the parts so formed can be united by welding, screws, or bolts. Hardman's gate (Fig. 134) is in every respect excellent; it is quaint, vigorous, and illustrative of a true mode of working metal. The two foliated railings (Figs. 135, 136) are also very meritorious. They are simple in design, and their parts are well fastened together. I advise very strongly that the student carefully consider the illustrations which have accompanied this lesson. The same subject will be continued in the next chapter, in which further examples of ornamental iron work will be given from ancient and modern sources to which I am anxious to call the attention of the student.

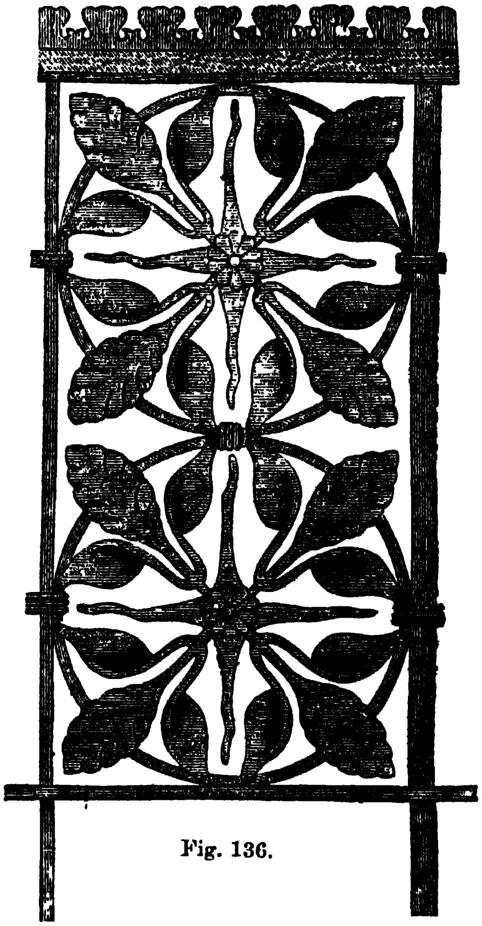

Fig. 136.

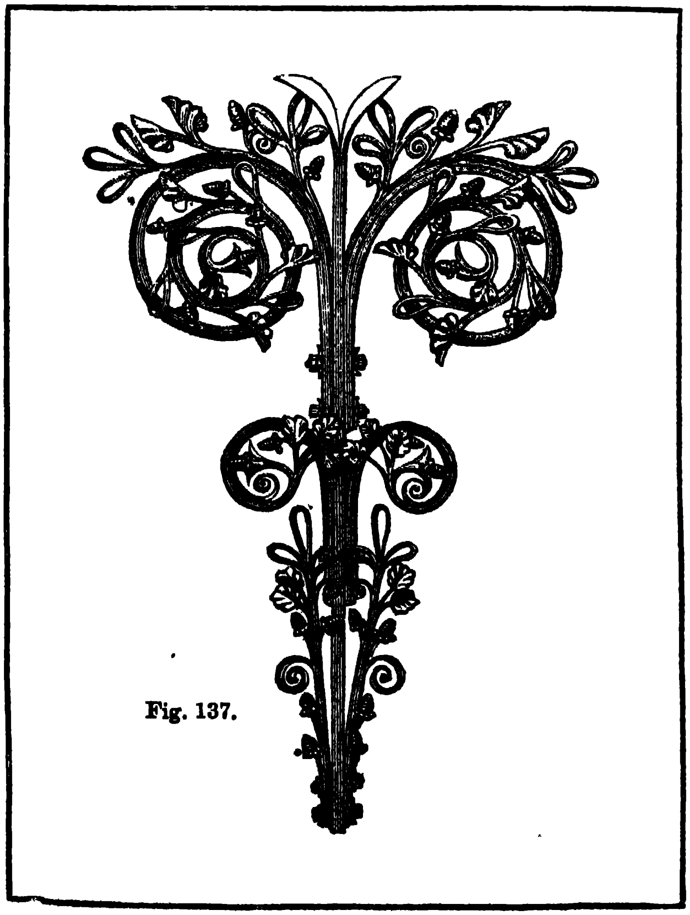

Fig. 137.

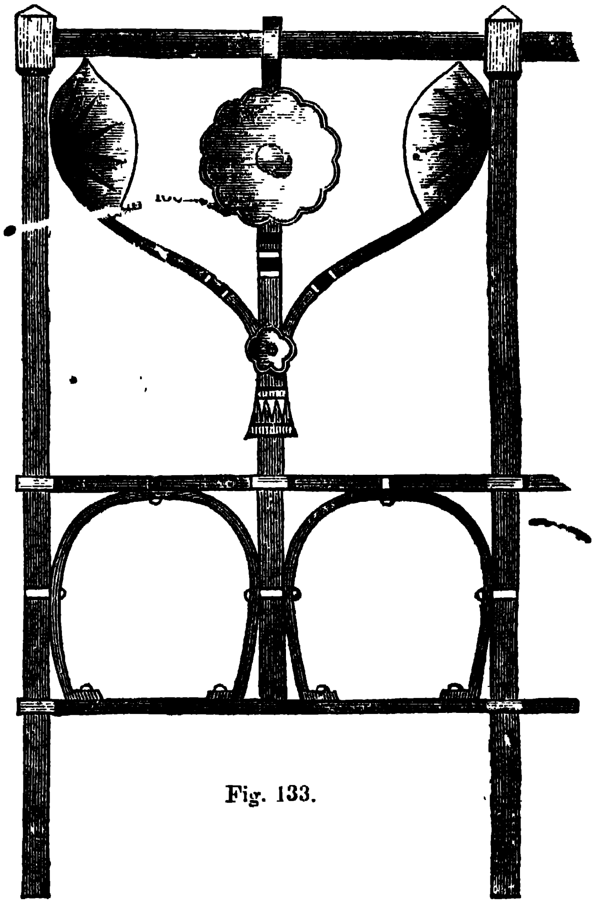

Fig. 133.

BUILDERS' QUANTITIES AND MEASUREMENTS.—VIII.

BY E. WYNDHAM TARN, M.A.

CARPENTRY.

The work of the carpenter is the framing of timber in roofs, floors, and partitions, the construction and erection of centerings for brick or stone arches, fixing bracketing for cornices of rooms, battening the walls for plastering and the roof for slating, laying rough boarding, framing and fixing solid sash and door frames, erecting wood fencing to gardens, and all woodwork of a heavy or rough description.

In measuring timbers used in building, care must be taken to keep them separate, according to the position and manner in which they are fixed; but all are measured by the cubic foot, the length and scantling, that is breadth and thickness, being entered under each other in the dimension book, and described according to the labour upon them. Timber which is laid in walls with little or no labour upon it beyond cutting into lengths and fixing is taken under one head as bond, plates, sleepers, templates, lintels, etc.; deduct half the length of the bond timber which is cut out of openings. In single-joisted floors the timbers are taken as "framed in joists;" in double-joisted floors, where the bridging and ceiling joists are notched on binders, as shown in Fig. 136 of Lesson XIV. on "Building Construction," take the joists as in single floors and the binders separately as "framed in binders," and if the binders are themselves framed into other timbers called girders, as in Fig. 117 of Lesson XIII. on "Building Construction," the girders are put into the same category as the binders. Trimmers and trimming joists round openings in single-joisted floors are classified with binders and girders. Bressummers to carry walls over openings, or girders sawn down, reversed, and bolted or trussed, are placed by themselves as "framed girders, etc.," the iron trusses and bolts being taken by weight.

The timbers of trussed roofs are measured their full length, allowing for tenons, scarfings, and other joints, as described in Lessons XII. and XIII. on "Building Construction." When the scarfing of long tie-beams is made as shown on Figs. 95, 96, etc., the length of the scarf must be measured twice, in order to get at the timber used, keys and wedges being numbered, and the iron bolts taken by weight. The timbers are described as "cube framed in trusses;" the common rafters, purlins, gutter plates, and such timbers as do not form part of the trusses are taken together and kept separate from the trusses. If any of the timbers are planed to a smooth face for staining or painting, the labour is taken separately, and measured by the foot superficial.

When the ridge, hip, or valley pieces are less than three inches thick they are measured by the foot superficial, and all cuttings by the foot run. Tilting fillets and feather-edged eaves-boarding for raising the slates at the eaves, are taken by the foot run; also take the run of hip and ridge rolls.

The boarding or battening of roofs for slates or any other covering, is taken by the square of 100 superficial feet, stating the thickness, width, and distance apart of battens. Valley and gutter-boards are taken by the foot superficial.

In measuring the king-post of a trussed roof, as shown at Fig. 151 of Lesson XV. on "Building Construction," one only of the pieces cut out to form a shoulder is to be deducted from the cube of the timber; and in queen-posts deduct only half of one of the pieces cut out. Blocks to support the purlins on the rafters are numbered: also number all wood-bricks inserted into a wall for fixing the joiner's work. Drips and cesspools in gutters are to be numbered.

Measure herring-bone strutting placed between the joists of a floor, as shown in Fig. 133 of Lesson XIV. on "Building Construction," by the foot run, taken across the joists. Sound boarding placed on fillets half way down the joists, as shown at Fig. 134, is taken by the square of 100 superficial feet, measured over the whole surface of the floor, without any deductions for thickness of joists. Sometimes, however, the exact measurement is taken, deducting the joists, and must then be described as "nett."

In measuring quarter partitions, as shown by Fig. 181 in Lesson XVIII. of "Building Construction," the timbers forming the trusses, as head, sill, and braces, are taken as "cube in trusses." The quarters which fill in th [illegible] trusses, and to which the plasterer attaches his laths, are cubed separately, and may be added to the common rafters or joists.

Bracketing for plaster cornices of ceilings and cradling for shop fronts are measured by the foot superficial, taking the length by the girth. Circular work may be taken double measure, and all angular brackets numbered in addition to the superficial measurement.

When walls are battened out to receive the plaster the battening is measured by the square of 100 feet, deducting all openings, stating the thickness, width, and distance apart of the battens.

Centerings to vaults and other large arches are measured by the square of 100 feet, taken on the soffit of the arch. Centerings to smaller arches are measured by the foot superficial, and turning pieces by the foot run.

Where timbers are cut in the form of a circle, take the cube of the original timber required to allow for the sweep, and measure the labour by the foot run. In the case of arched heads to solid door or window frames, take the run of the curve and describe as framed, rebated, and beaded circular heads, glued up in thicknesses. The straight parts of solid door-cases and window-frames are measured by the foot cube and described, oak sills being taken separately from the fir frames. In measuring square-headed frames the head must be measured six inches longer than the outside width of the frame, and the jambs two inches longer than the height, to allow for stubs into the sill.

Weather boarding and rough boarding is measured by the square of 100 feet.

In measuring wood fences formed of cleft oak pales with arris rails and oak posts, take the length in feet and bring it into rods of 16 feet 6 inches, describing the height. If there is an oak plank at the bottom or capping on the top, measure them separately by the foot run. Field gates, gate posts, etc., are numbered and the size described.

Guard fences, of cleft rails and posts are taken by the rod of 16 feet 6 inches.

Timber which is only used temporarily, as in shoring, needling, strutting, etc., is taken by the foot cube, and entered as "use and waste."

Sawyer. Measure the sawing of large timber by the foot superficial, and bring it into squares of 100 feet. If the scantling of the timber is 6 inches or less, take the sawing by the foot run.

We shall now illustrate the foregoing rules by a series of dimensions of the various materials and labour required in the carpenter's work of a building.

20)	15 9		C. fir joists.
	0 11		
	0 2½	60 2	
	45 0		Ditto wall plate.
	0 4½		
	0 3	4 3	
2)	45 0		Ditto bond timber.
	0 9		
	0 3	16 11	
2)	1 9		Ddct.
	0 9		
	0 3	0 8	
		16 3	
2)	15 9		Ditto trimmers.
	0 11		
	0 3	7 3	
20)	15 0		Ditto joists.
	0 5		
	0 2	20 10	
4)	24 0		Ditto sleepers.
	0 4		
	0 3	8 0	

20)	25 0 0 3 0 2	20 10	Ditto ceiling joists.
4)	16 0 1 2 0 7	43 7	Ditto binders.
3)	16 0 1 1 1 1	56 4	C. fir girders, sawn down, reversed, and bolted together.

No. 30 wrought iron bolts, ½ in. diameter, 15 in. long, with heads and screw nuts.

3)	16 6 1 1 0 7	31 3	C. fir tie beam.
3)	5 6 0 7 0 9	7 3	Ditto king-post.
	4 0 0 7 0 3	0 7	Ddct. shoulder.
		6 8	
2)	25 6 0 7 0 7	17 4	Ditto purlins.
6)	4 6 0 7 0 4	5 3	Ditto struts.
20)	12 0 0 4 0 3	20 0	Ditto common rafters.
2)	25 0 0 4 0 3	4 2	Ditto pole plate.
	25 6 0 11	23 5	1½ in. ridge piece.
2)	24 0 1 3	60 0	1 in. gutter boards and bearers.

No. 4 drips, 2 cesspools.

2)	24 6 12 0	588 0	¾ in. battening, 3½ in. wide, laid for countess slating.
2)	24 6	49 0	Tilting fillet.
	24 6	24 6	2 in. ridge roll.

No. 6 blocks to purlins.
„ 24 wood bricks.

	24 0	24 0	Herring-bone strutting.
	24 0 15 0	360 0	1 in. sound boarding on two fillets.
	24 0 11 0	264 0	¾ in. battening to walls, plugged, with battens 2¼ wide, 10 in. apart.
	6 6 3 6	22 9	Ddct. opening.
		241 3	

3)	15 6 0 6 0 6	11 8	C. head and sill to trussed partition.
	16 6 0 5 0 6	3 5	Add braces.
	23 0 0 5 0 6	4 10	Add ditto.
2)	8 0 0 6 0 6	4 0	Add door posts.
		23 11	
10)	11 0 0 6 0 3	13 9	Ditto quarters.
7)	3 0 0 6 0 3	2 8	Add.
		16 5	

No. 2, 1 in. wrought-iron bolt, 12 ft. long, with nuts, plates, and screws.
„ 2, ½ in. bolts, 12 in. long, with nuts and screws.

	90 0 1 6	135 0	Bracketing to cornice.

No. 4 angle brackets.

2)	6 6 5 0	65 0	Centering to vaults.
4)	5 9 0 9	17 3	Ditto to arches.
6)	3 6 1 6	31 6	Ditto trimmers.
		113 9	
4)	3 6	14 0	Turning pieces, 4½ wide.
2)	17 6 0 4 0 3	2 11	C. fir, wrought, rebated, and beaded (or "proper") door-case.
2)	10 0 0 4 0 3	1 8	Ditto, ditto, window frame.
		4 7	
2)	6 3	12 6	Circular heads to window-frame, rebated, beaded, and glued up in thicknesses, 5″ × 3″.
2)	4 6 0 4 0 3	0 9	C. oak, wrought and weathered sill.
4)	12 6 8 0	400 0	1 in. weather boarding.
	13 0 3 0	39 0	Ddct.
		361 0	
2)	110 0	220 0	5 feet cleft oak pales, with 2 arris rails and oak posts, 9 ft. apart.

45 0	45 0 265 0	Add.
265 0	265 0	1 in. oak plank, 12 in. wide to ditto.
265 0	265 0	Oak capping to ditto.

No. 2, oak gate posts, 12″ × 12″, 5 feet high.
„ 1, 5-bar field gate, 9 ft. wide with sawn rails.

44 0 1 2 0 7	29 11	C. fir, use and waste for shoring.
20 0 0 11 0 3	4 7	Add.
6 0 0 6 0 6	1 6 36 0	Add.
21 6	21 6	Arris gutter, 4 in. deep, ¾″ deal.
10 3	10 3	Water trunk, 4½ in. square, ¾″ deal.

No. 1 shoe for trunk. 2 joints for ditto. 1 hopper head.

2)	5 6 2 6	27 6	1 in. deal, feather edge louvre boarding.
3)	16 6 3 4	165 0	Planing fir, tie beams.
3)	5 6 2 8	44 0	Add king posts.
2)	25 6 2 4	119 0	Add purlins.
6)	4 6 1 10	49 6	Add struts.
3)	16 0 2 2	104 0 481 6	Planing underside of girders.

SAWYER.

4)	42 0 1 2	196 0	Sawing fir.
10)	24 0	240 0	Ditto 6 in. oak rails.

ABSTRACT.

Cube.		Superficial.		Run.		Numbers.	Smith.
Fir in bond, etc. ft. 4 3 16 3 8 0 4 2 32 8 Fir in joists, etc. ft. 60 2 20 10 20 10 20 0 16 5 138 3 Fir framed in trusses. ft. 7 3 43 7 31 3 6 8 17 4 5 3 23 11 135 3 Fir framed in girders, sawn down, and reversed. 56 4	Fir proper door-case and window frame. ft. 4 7 Fir, use and waste in shoring. ft. 36 0 Oak sill, weathered. ft. 0 9	1½ in. ridge piece. ft. 23 5 1 in. gutter board and bearers. ft. 60 0 Planing fir. ft. 481 6 ¾ in. battens, 3½ wide, laid for countess slates. ft. 100)588 0 5sq. 88ft. 1 in. soundboarding, on two fillets. ft. 100)360 0 3sq. 60ft. ¾ in. battening to wall, plugged, 2¼″ wide, 10in. apart. ft. 100)241 3 2 sq. 41 ft.	Bracketing to cornice. ft. 135 0 1 in. deal louvre boarding, feather-edged. ft. 27 6 1 in. deal weather boarding. ft. 100)361 0 3 sq. 61 ft. Centering to arches. ft. 113 9	5 ft. cleft oak pales, 2 arris rails, oak posts 9 ft. apart. ft. 16·6)265 0 16 rods. 1 in. oak plank to fence, 12 in. wide. ft. 265 0 Oak capping to fence. ft. 265 0 Tilting fillet. ft. 49 0 2 in. ridge roll. ft. 24 6 Herring-bone strutting. ft. 24 0 Turning pieces, 4½″ wide. ft. 14 0	Circular head to window-frame, glued in thicknesses, 5″ × 3″. ft. 12 6 Arris gutter, 4″ deep, ¾ in. deal. ft. 21 6 Water trunk, 4½″ square, ¾ in. deal. ft. 10 3	Shoe to water trunk. 1 Joints to ditto. 2 Hopperhead ditto. 1 Blocks to purlins. 6 Wood-bricks. 24 Angle pieces to bracket of cornice, 18″ girt. 4 Drips to gutter. 4 Cesspools ditto. 2 Oak posts, 12″ × 12″, 5 ft. high. 2 Five-bar field gate, 9 ft. wide, with sawn rails. 1	½ in. w. iron bolts, 15″ long, with heads, nuts, and screws. 30 Ditto, ditto, 12″ long. 2 1 in. w. iron bolt, 12 ft. long, nuts, plate, and screws. 2 SAWYER. Superf. Sawing fir. ft. 100)196 0 1 sq. 96 ft. Run. Sawing 6 in. oak rails. ft. 240 0

In applying the foregoing rules to the measurement of carpenter's work, all the materials and labour are supposed to be supplied by the carpenter or the contractor who employs him. If, however, the timbers and other materials are delivered to the building by the person for whom it is being erected, and at his expense, then the carpenter's work can be measured in the manner before described, and entered as "Labour and fixing," or as "Labour and nails" which includes glue, attendance on sawyers, etc. But it is more usual in this case to take the roofing, flooring, partitions, centering, rough boarding, weather boarding, etc., all by the square of 100 superficial feet, describing the character of the work to be done.

Timber is purchased by the "load" of 50 cubic feet. Planks, deals, and battens, 2½″ and 3″ thick, by the hundred of 120;

planks being 11 inches wide, deals 9 inches, battens from 3 to 7 inches wide.

To find the cubical contents of a "baulk" of timber in its rough and uncut state, take one-fourth of the girth round the *middle*, square it, and multiply by the length; the baulk being slightly tapered, or smaller at one end than the other.

When 3-inch deals or battens are cut into two equal thicknesses, they are called "one-cut;" if into three equal thicknesses, they are termed "two-cut;" if into four equal thicknesses, "three-cut;" and so on, according to the number of saw cuts required. One and a half inch deal is generally understood to be the same as "one-cut," being got out of three-inch deal by one saw-cut down the middle; 1-inch deal as "two-cut;" ¾-inch as "three-cut," and so forth.

FARMING AND FARMING ECONOMY.—XI.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

ARABLE VERSUS PASTURE LAND.

THE question of arable versus pasture land is interesting to the economist, the philanthropist, and the agriculturist. This many-sidedness constitutes its chief difficulty, and is the cause of much difference of opinion. Mr. Mechi well represents a class of thinkers who view this subject from a somewhat speculative standpoint. In a lecture before the Farmers' Club, upon the undeveloped powers of British agriculture (Nov., 1868), he thus speaks of what appears to him to be one of the greatest causes of agricultural non-development. Grass land or permanent pasture "is the grand field to which we must look for development and progress. One half of the United Kingdom is in permanent pasture. The last Board of Trade returns give 22,156,541 acres in 1867 as against 21,174,787 acres in 1866, showing an increase of 981,754 acres in grass land.[*] These returns are exclusive of heath or mountain lands." Again, "We have heard too much lately about laying down land to grass and depending upon foreign countries for corn. Judging from the latest statistics, that opinion appears to have been acted upon. I protest against this mistaken practice, as most injurious to the country." The evils of this system are summed up by Mr. Mechi as "starving the people and depriving them of employment." Figures are also quoted to show the immensely greater produce derivable from arable than from pasture land. "Our 11,500,000 acres in corn crops produce on an average an annual sum of about £83,000,000, besides straw. What do our 22,000,000 acres of permanent pasture produce? According to my rough or approximate estimate, only about £50,000,000, or about 43s. per acre, while our 11,500,000 acres of corn, produce £8 per acre, besides about £2 worth of straw."

Neither is the opposite policy of laying down land to grass without supporters. It is confidently argued that Great Britain is not a corn-growing, but a grazing country; that the climate is favourable to grass and unfavourable to cereals; that in live stock she is pre-eminent, while in the corn trade she competes at a decided disadvantage with foreign countries. Therefore—for this is the corollary of the proposition—let us lay our land down to grass, grow beef and mutton, and purchase corn in the markets of the world at large! Both these views are alike unpractical, because they never will influence the actions of those most directly interested in the question at issue. The true method of approaching this question was indicated by Mr. Clare Sewell Read, M.P., at the February meeting of the Farmers' Club, 1870. He said, "They were constantly lectured on their duty to the public. They were constantly told that in these days it was the duty of the farmer to grow more; but he believed that that was a secondary duty, and that the main duty of a farmer was, if possible, to make his farm pay. He, for one, knew perfectly well that pasture land might be broken up and might produce more meat, and yet what was done might be an utterly losing game." Mr. Read's tersely-expressed views may fairly be looked upon as representing the opinion of the majority of agriculturists. It is a thoroughly practical conclusion, based upon the solidity of existing institutions, but cannot be considered as an answer to speculative arguments founded upon abstract principles rather than upon present circumstances. Rightly or wrongly, we have forsaken the coercive methods of regulating industry adopted by our forefathers. We no longer artificially check the flow of precious metals from our shores, or frame laws to protect certain interests. We can hardly imagine the revival of the laws limiting the number of sheep possessed by one man to 2,000 (Henry VIII., 13 of 25), forbidding any man to occupy more than two farms; or land to be laid down in pasture (Froude's "History of England," vol. i., page 34). Such acts were passed in accordance with views similar to those held by Mr. Mechi, and, if based upon correct principles, they ought to be, if not repealed, enforced. Inclining, as we do, to the general principle of non-intervention, as most likely to encourage the art of agriculture, we are bound to agree with Mr. Read that the relative net profit, and not the relative productiveness of the two classes of land, should be the crucial test applied. We believe, also, that these views would be supported by economists; for if pasture land were more profitable than arable land, then would the labour expended in converting and maintaining it as arable land be, to some extent, unproductive, and would be better diverted into other channels. The same argument might be used to dispose of the supposed advantage accruing from the increased capital required in the case of such broken-up lands; for if capital is not profitably invested it will inevitably be withdrawn and placed in some more remunerative enterprise.

Those who urge the wisdom of ploughing up grass lands do so on the following grounds:—First, that the amount of human food would be increased—according to Mr. Mechi, quadrupled; second, that an immense field for labour would be opened; third, that a safe investment would be offered for native capital. To which splendid reasons we have only one answer to make—That so long as an individual finds his grass fields more profitable than his arable fields, he probably will keep them as they are.

But the question of arable versus pasture land cannot be summarily settled. There are so many kinds of land, that it is impossible to lay down a law applicable alike to all. It becomes necessary to classify our pastures, and in so doing we may find it advisable to allow some to remain as grass, while others would be more profitable as arable land. All pastures may be arranged under one or other of the following heads:—

1st. The best bullock-grazing grounds, such as abound in Lincolnshire, the Midlands, Somersetshire, and more or less in every county.
2nd. Clay land pastures of fair or good quality.
3rd. Poor clay land pastures.
4th. Light land pastures of fair or good quality.
5th. Poor light land pastures.
6th. High-lying mountain land, precipitous in character and ungenial in climate.
7th. Waste lands, such as downs and heaths.

THE BEST BULLOCK LAND.

All agriculturists agree that lands of this class are better left in grass. Testimony to this effect might be adduced to almost any extent, but we forbear, presuming that such opinions are based upon sufficient reasons; and we prefer laying before our readers some of the most weighty arguments which support this conviction. Good grass lands command a higher rent, and a greater profit to the tenant, than any arable land. Secondly, it requires many years to bring them into the condition of old sward. Easy as it is to break up a pasture, or cut down a tree, it is about equally difficult to replace the one as the other. This is understood by agriculturists, who well know that the peculiar condition of good old turf is only arrived at after land has been laid down for many years. Thirdly, such land is a safer property; its produce has risen in value, and may rise higher; it is less troublesome, and less subject to casualties.

According to Mr. Morton ("Farmer's Calendar," page 524), one acre of first-rate grazing land in Lincolnshire will, under the best circumstances, feed an ox and a sheep from New May Day

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[*] The returns for 1870 state the area under corn in the United Kingdom as 11,755,053 acres, or 322,000 acres more than in 1867. The extent in permanent pasture was in the same year 22,085,295, which was distributed as follows:—

Great Britain	12,072,856 ac., or	40	per cent. under permanent pasture.
Ireland . .	9,990,968 ,,	64	,, ,, ,, ,,
The Islands .	21,471 ,,	19	,, ,, ,, ,,
	22,085,295		

This therefore indicates a decrease of permanent pasture since 1867.

to Old Michaelmas; the former will gain 20 stone, or 290 lbs., and the latter 10 lbs. per quarter, or 40 lbs., in the time. Taking 7d. per lb. as a very moderate price for this produce, we have 320 lbs. at 7d., or £9 6s. 8d., as representing its value. Or if we assume, with Mr. Morton, that the average produce of such land is 12 tons per acre of grass, which will be equivalent to 3 tons of hay, this represents, at £3 per ton, £9 per acre.

Now it requires very good land, very good farming, and very propitious seasons, to produce £10 per acre average upon cultivated fields. This is clearly shown by the following statement of the crops necessary to produce such a sum:—

		£	s.	d.
First year.	20 tons of swedes, realising, when fed off, 5s. per ton	£5	0	0
Second year.	60 bushels of barley, at 4s. 6d. per bushel	13	10	0
Third year.	3 tons of clover hay, at £3 (consuming value)	9	0	0
Fourth year.	45 bushels of wheat, at 6s.	13	10	0
		4)41	0	0
		£10	5	0

To set against this income would be a manual labour bill of £2 (for heavy crops require extra labour), a horse labour account of £1, and a seed bill of 10s. per acre. Farmers who grow such crops generally have heavy purchased manure and food accounts; but since we have assumed the land to be of rich quality, we shall place these at £1 per acre. Without taking into account the other numerous charges connected with arable land—such as blacksmiths', joiners', saddlers', and other tradesmen's bills, new implements, etc., we are compelled to reduce the gross profits, to be divided between landlord and tenant, from £10 to £5 10s. per acre.

We have presented two cases of arable and pasture land, both under very favourable circumstances; but in doing so we have not forgotten the chances of season and disease. These items may, however, be considered as cancelling each other, and the balance will accordingly appear on the side of the grass land.

CLAY LAND PASTURES,

Whether of good or bad quality, ought not to be ploughed up. These lands are intractable under tillage; they are essentially adapted for growing corn rather than root and forage crops, and for these reasons are less likely to be profitable under cultivation than lighter soils. Let those who insist upon breaking up such pastures reflect upon the advantage of employing the necessary capital in improving the same land in its present condition. Let it be drained, limed, annually dressed with liberal applications of superphosphates and guanos, for at least four seasons, plentifully stocked with sheep and cattle receiving cake and corn, the land being judiciously managed in every other respect, and we venture to predict that it will repay the enterprising landlord or tenant with a richer harvest than even waving wheat fields could afford.

LIGHT LAND PASTURES

Offer a more promising field for those who recommend tillage as preferable to grass. Such land, when broken up, yields plentiful supplies of root and forage crops, and is well adapted also for barley and wheat. It is land which will grow anything, and is worked at comparatively small cost. On the other hand, it is not so well adapted for growing grass as clay soils, being susceptible of injury from drought, and not unlikely to "burn" in the summer months. If such lands do not produce sufficient grass, the question becomes easier of solution, and we would unhesitatingly recommend the plough.

HIGH-LYING MOUNTAIN LAND

Will probably remain in grass, although it may be improved by a short course of tillage. Thus, on the Lammermuir Hills it is a common practice to break up the inferior pastures, and after taking a crop of oats and turnips, to lay them down with a suitable mixture of grass seeds.

WASTE LANDS, SUCH AS DOWNS AND HEATHS,

Offer the most promising prospect for converting grass into arable land. It is evident that the heath farmers of Lincolnshire, the wold farmers of the same county and of Yorkshire, and the occupiers of down lands in many of the southern and western counties, have reaped advantage from the breaking up of such lands. Take, for example, the case of the Lincolnshire heath, a district described in the middle of last century as covered with heath, fern, and gorse, the only fences being the furze-capped walls of sand that enclosed the rabbit warrens.

In 1789 Arthur Young describes the enclosures as having been made within the last twenty years. The effect of arable culture here has been marvellous. Rents have risen from 1s., 2s., and 3s. per acre to 30s. tithe free. The land is naturally easily worked, and is adapted for turnips and barley husbandry, as well as for sheep. "Every part of it," writes Mr. John A. Clarke, "is under culture, abounding with spacious, well-constructed farm buildings, strong well-fed working horses, and immense folds of sheep. The barren sheep-walk and warren have been clothed in fruitfulness, and their richness preserved by unremitting weeding and unstinted manuring." Such examples of the advantage of converting what may be called pasture into arable land abound; but they may be more correctly spoken of as successful instances of reclaiming waste lands.

We have now considered all the classes into which the pasture lands (using the word in its widest sense) may be divided. We may conclude that espousing either side of the question of arable versus pasture land is likely to lead into error, and that the true method of approaching the subject rests in appreciating thoroughly two important facts—first, that under our present political and social economy it is merely a question of profit and loss; and, secondly, that there are many classes of pasture land, and that one rule cannot be made applicable to all.

SHIP-BUILDING.—IX.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE FRAMING OF IRON SHIPS (*continued*).

In this paper we propose to give some account of the system of framing adopted in the iron-built armoured vessels of the Royal Navy. This system—usually known as the "bracket frame" system—is an outgrowth of the longitudinal system, of which Mr. Scott Russell is the author; but it differs from the earlier plan in many very important particulars, and is, by general consent, acknowledged to be better adapted than any other to the special requirements of iron-clad war-ships. Since the first iron-clad, the *Warrior*, was built, considerable changes have been made in the methods of constructing such vessels, and the bracket-frame system itself has been since introduced; but with these changes we cannot concern ourselves here, and shall restrict attention to arrangements such as would now be considered good.

Mr. Reed, the late Chief Constructor of the Royal Navy, to whom the introduction of the bracket-frame system is due, thus briefly sums up its characteristics:—"The objects of the invention and introduction of this system were to save weight, to simplify workmanship, and to add both to the strength and safety of the ship. The characteristic features of the system are the adoption of an inner bottom, and of short angle-irons connected by bracket-plates, in place of staple and other forged angle-iron work. A great increase of longitudinal strength is gained by the use of much deeper longitudinal frames than those of the *Warrior* and other of the earlier iron-clads. Another important feature resulting from the employment of deep longitudinals, is that the space between the two bottoms is roomy, and easy of access for cleaning and painting—operations which are essential to the preservation of an iron structure. Facilities are also offered by these arrangements for letting in water between the bottoms to serve as ballast, the space being so divided into watertight compartments as to enable the officer to regulate the trim of the vessel by filling the fore or the aft spaces. Provision is, of course, made to pump out any compartment when required."*

The sectional view of a portion of the framing of a ship so built, in Fig. 23, will enable the principal features of the system to be understood more clearly. The main frames will be seen to consist of strong continuous longitudinal girders, L L, placed at the centre-lines of the alternate strakes of bottom plating. The central keel, or keelson, K, stands upon a flat keel formed of two thicknesses of plating. There is an internal skin upon the inside of the longitudinals, and this, being made watertight, forms the inner boundary of the double bottom. It is also customary to make the centre keelson, or vertical keel, watertight, as well as the fourth or fifth longitudinal frame out from the keel, thus subdividing the space in the double bottom.

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* "Ship-building in Iron and Steel," page 110.

The provision of longitudinal strength is, therefore, similar in principle to that previously described, and all that was previously said respecting the necessity for carefully shifting and fastening the bolts of the longitudinals applies here also. In the arrangements of the transverse framing, an entirely new method is adopted. The transverse frames are placed about 4 feet apart, instead of being 12 or 14 feet apart, as are the partial bulkheads in Mr. Scott Russell's system. The frame angle-irons, F F, to which the outside plating is riveted, are fitted in short lengths between the longitudinals; but the reversed frames, C C, to which the inner skin is fastened, are continuous, notches being cut in the inner edges of the vertical keel and the longitudinals, in order to allow the reversed frames to pass through unbroken. In consequence, the angle-irons on the inner edges of the longitudinals have to be worked in short lengths between the continuous transverse angle-irons; while the angle-irons on the outer edges of the longitudinals are continuous, like the plates to which they are attached. This plan leaves a large reserve of longitudinal strength, and at the same time provides a continuous transverse tie from side to side, such as does not exist in a vessel built on the ordinary longitudinal system. Of course, it is not meant that even in the latter case the indirect transverse connection at the partial bulkheads is not a strong one; but on the whole, a direct connection, such as is provided at frequent intervals in the iron-clads, seems preferable.

To connect the frame and reversed frame angle-irons to each other as well as to the longitudinals, "bracket" plates, B B (Fig. 23), with short angle-irons on their ends are employed, and they have given a name to the system of construction. Their usefulness will be obvious, and so will be the simplicity of workmanship, combined with strength of connection, that results from their employment. By means of them a very small weight of material is made to supply ample transverse strength to the lower part of the hull, and at the same time to furnish that support to the outside plating which is wanting in vessels with widely-spaced partial bulkheads. The primary character of the longitudinal framing is left untouched; but while the transverse framing is subordinated thereto, it is made strong as well as light. Throughout the length of the double bottom—which would be about two-thirds of the total length of the ship—the bracket-plate arrangement is conformed to for four out of every five or six of the transverse frames. At intervals of about 20 or 24 feet, however, solid plate frames are substituted for brackets, and are made watertight, thus further subdividing the space between the two skins, and forming compartments of moderate size. This subdivision, besides possessing the advantages alluded to above, adds considerably to the safety of the ship in case the outer plating is broken, because the water which might enter under such circumstances would only have access to a very limited space.

Before and abaft the double bottom it is not customary to use bracket-frames, but to fit "lightened plate-frames" instead. These are formed very much in the same fashion as the partial bulkheads in Mr. Scott Russell's ships, only they are not more than 4 feet apart, and are lightened considerably by cutting large pieces out of the central portions of the plates. This principle of lightening all parts of the framing to the greatest possible extent consistent with a retention of a proper amount of strength is carried out most thoroughly in the iron-clads, and the aggregate saving in the weight of hull thus effected is very considerable. As another example of this practice, we may refer to the longitudinal frames. These are formed of very deep plates, with angle-irons on the edges; and at the stations of the transverse frames, which occur at intervals of 4 feet, these plates are necessarily weakened by the lines of holes punched to receive the rivets in the connecting angle-irons, as well as by the scores or notches cut out to permit the passage of the continuous transverse frames. To leave the full strength of the plates untouched between these unavoidably weakened sections would obviously be unwise, because there would then be a great want of uniformity in the strength of the longitudinal frames, and that would be contrary to one of the fundamental principles of construction. What is actually done is to cut large holes in the parts of the longitudinals lying between the stations of the transverse frames, the sizes of the holes being so determined as to leave the plate at least as strong in wake of them as it is at the adjacent weakened sections; and so a saving of weight is effected without any loss of strength. In arranging the fastenings of the butts of these longitudinals, it is also the practice to aim at a strength as nearly as may be equal to that of the unavoidably weakened sections, and greater uniformity of strength is thus ensured.

Most of the longitudinals are continued right forward to the stem, and are strongly connected with it, thus strengthening the bow most efficiently for use in "ramming," a method of attack that seems likely to be much used in future naval engagements. Towards the stern special methods of framing are required, in order to provide the necessary strength to resist the strains caused by the screw propellers, which are by no means of small amount in these large swift vessels. On this account it is customary in ships with single screws to end all except two or three of the longitudinal frames at a bulkhead 16 or 20 feet before the stern-post; but in twin-screw ships the longitudinals are sometimes run right aft to the stern-post. The transverse framing at the after end is formed by lightened plates, with stiffening angle-irons on the edges, and it has a very important part to play. It is satisfactory to know, however, that in these powerful steam-ships, with engines developing from 6,000 to 8,000 horse-power, no signs of weakness have been found at the sterns, and the fact constitutes not the least important evidence of the superiority of iron to wood.

In constructing armoured ships special requirements have to be met, and the builder has to consider how best to combine lightness with strength and safety, in order that he may be able to carry thicker armour on the sides and heavier guns in the batteries. He has also to devise arrangements that will turn the armoured portion of the vessel into a strong target, and at the same time to ensure efficient connection between that part of the structure and the unarmoured under-water part of the hull. The system of bracket-framing is, of course, only used for the unarmoured part, and it would end at the height where the armoured side begins, say 5 or 6 feet below the line at which the ship is intended to float when fully equipped. Above that height the main framing consists of strong transverse frames spaced about 2 feet apart; and the governing idea of the structural arrangements is to make the vessel's side strong against the impact of shot and shell. Only the leading features of these arrangements can be described, and to illustrate them Figs. 24 and 25 have been drawn. In both these Figures it will be observed that the armour-plating ends upon a longitudinal shelf, or recess-plate, marked S; this shelf is really the uppermost longitudinal frame of the set to which L L (Fig. 23) belong. Behind the armour come the planks of wood forming the "backing," and upon the inner side of this comes the "skin-plating," worked in two thicknesses. The frames, F F, within the skin-plating, are those just aluded to as having a spacing of 2 feet only. This strong combination is further strengthened by horizontal frames or girders, G G, worked outside the skin-plating at intervals of about 2 feet, and crossing the inside frames at right angles. As a final result a very strong target is formed, which, when tried at Shoeburyness, proved to be capable of resisting most efficiently the great and sudden shocks caused by the blows of projectiles.

To efficiently connect the parts lying above and below the armour-shelf of such a ship is obviously no easy matter, but the difficulty is well met by either of the plans in Figs. 24 and 25. For example, in Fig 24 the alternate frames, F, are continued down, and directly connected with the continuous transverse frames, C C (Fig. 23), thus completing the transverse tie from gunwale to gunwale at intervals of 4 feet. In that case, however, the inner skin is not worked directly upon the frames up to the height of the armour-shelf, but its upper part is placed vertically at some distance within the frames, and formed into what is termed a "wing-bulkhead," well stiffened by angle-irons. The upper part of such a bulkhead is shown in Fig. 24, and is marked D; its lower edge would meet the inside of the frames at a longitudinal, which would be made water-tight, thus shutting off the wing-spaces from the double bottom proper. Against dangers resulting from penetration of the thin outer plating immediately below the armour by shot, by torpedoes, or by ramming, the provision of these wings is obviously advantageous, and as transverse watertight partitions are fitted in the wings at frequent intervals, such penetration would only admit water to limited spaces, leaving the vessel but little the worse so long as the wing-bulkheads were not broken through. As a means of giving longitudinal strength to the structure, also, such bulkheads are not to be despised.

The arrangement in Fig. 25 differs from that in Fig. 24, in that there is no wing-bulkhead, the inner skin being worked directly upon the frames quite up to the height of the armour-shelf, which is made up of a very broad longitudinal, forming a watertight top to the double bottom. The frame, F, behind the armour, is not continued down (as in Fig. 24) to meet the continuous transverse frames, but is ended upon the armour-shelf, and the double-angle irons on the outer edge are turned inwards so as to be riveted to the shelf-plate. A very strong indirect transverse connection is, however, formed at intervals of four feet by means of the deep plate-frames fitted beneath the shelf, and the angle-irons on their edges. Instead of having the deck-beams formed with knees, as in Fig. 24, a simple plate, B, is used to connect them with the frames, F, and with the shelf-plate. All these changes spring from the fact that the double bottom is continued up to the armour-shelf, and wing-bulkheads dispensed with. The alteration has been made after full trial of the first-named plan; and it appears to have an advantage on the whole over the older arrangement, because it leaves the hold space greater than it would be with wing-bulkheads, and yet provides for strength and safety no less efficiently.

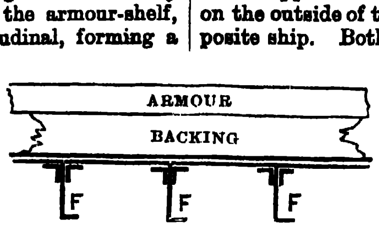


Fig. 26.

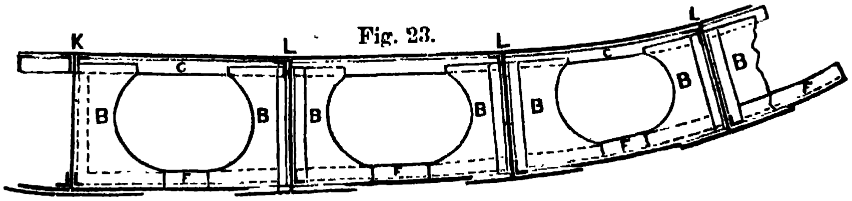


Fig. 23.

The sketches show in sufficient detail how the armour-shelf is connected with the bottom-plating and the skin-plating behind the armour. In order to show more clearly the arrangement and construction of the frames behind the armour, we have given in Fig. 26 a horizontal section of the side of an iron-clad. From this it will be seen that the frames F F are each made up of a deep reversed frame, with double angle-irons riveted to the outer edges. The external girders, G G (Figs. 24 and 25), are usually formed of deep-flanged angle-irons.

This brief description of some of the principal features in the framing of iron-clad ships is all that the space at our disposal permits. Before leaving the subject, however, it may be interesting to illustrate the great advantages that have resulted from using iron instead of wood for the hulls of such vessels. Mr. Reed states that in the *Caledonia*, one of the so-called "converted iron-clads," wood-built, the hull weighs 50 per cent. of the total weight of the ship and all she carries; whereas in the *Audacious*, an iron-clad built on the bracket-frame system, the hull only weighs 45 per cent. of the displacement. The saving in weight of hull obtained by the change in material and system of construction equals therefore 5 per cent. of the entire weight of ship and lading, and in the *Audacious* herself amounted to quite 275 tons. This saving can, of course, be applied in increasing the thickness of the armour, the power of the guns, the force of the engines, the speed of the ship, etc., making her far more formidable than she would otherwise be; at the same time it is accompanied by increased strength, safety, and durability, as compared with the results obtainable with wood ships. On all accounts, therefore, there is reason for congratulation at the change from wood to iron hulls that was made in our Navy simultaneously with the introduction of armour-plating. The French have continued to build mostly in wood; and quite recently statements have been made, apparently on good authority, that many of their earlier armoured ships have become so rotten as not to be worth repair; whereas the *Warrior*, and other of our iron built ships of equal age are still in good condition, and employed on active service.

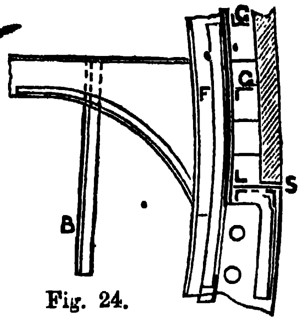


Fig. 24.

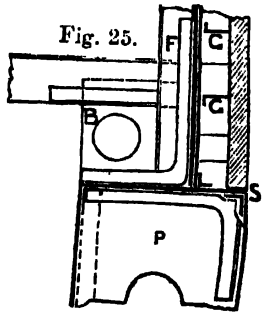


Fig. 25.

FRAMING OF COMPOSITE SHIPS.

In the great features of their framing, ordinary iron and composite ships are very similar. Stripping the iron vessel of her outside plating, with the exception of a strake near the turn of the bilge, and one—named the "sheer-strake"—near the level of the upper deck, and then adding diagonal plate-ties or riders on the outside of the frames, we arrive at the framing of the composite ship. Both have the main frames placed transversely, and supplemented by longitudinal keelsons and stringers; but in the composite ship the skin is of wood, and consequently requires the aid of diagonal ties, for reasons which have been fully explained in previous papers. Flat keel-plates are also commonly fitted in composite ships, and to them the external wood keels, into which the skin is rabbeted, are bolted. These keel-plates are continued up also for some distance on the wood stem and stern-post, which are thus more strongly connected with the wood keel.

The above is the common plan, and will be at once understood by comparison with the account of the framing of iron ships previously given. Many other very singular systems of framing have been used in particular cases, but have not been generally adopted. For instance, several vessels have been built with floors, and middle-line arrangements of keel, keelsons, etc., like those of wood ships, but with frames from the bilges upwards like those of iron ships. Other ships have been constructed with transverse frames formed of T-iron imbedded in wood, and strengthened by very numerous but slight diagonal ties. Others again have been built with no diagonal ties upon the frames; and probably greater variety might be found in the framing of this class than in that of either iron or wood ships, although it numbers comparatively few vessels.

In the "sheathed" ships of the Royal Navy we have examples of a novel principle of construction which may, perhaps, be best referred to in this paper. They are really iron vessels, with the skin-plating rather thinner than would generally be fitted in ships of equal size, and with wood planking or sheathing outside the iron skin. The primary object of this construction has already been stated to be the prevention of fouling by using copper or metal sheathing; and it will be obvious that so far as the framing is concerned, since there is a complete iron skin, the designer has as great a freedom of choice as in an ordinary iron ship. In the particular ships referred to the framing is arranged on a plan differing from either of those described. The main transverse frames are continuous from gunwale to gunwale, and are spaced seven feet apart. Each frame consists of a deep reversed frame, with a single angle-iron on its outer edge. In association with these frames, three or four strong longitudinals are fitted between the upper turn of the bilge and the middle line. Each longitudinal consists of a deep plate, running along inside the main transverse frames, with an angle-iron on its inner edge; and has its lower edge riveted to intercostal plates fitted between the transverse frames. The vertical keel is similarly formed. Intermediate between the main transverse frames, similar frames are fitted extending from the gunwale to the bilge, from which they are completed to the middle line by means of lightened plate frames fitted between the longitudinals. The spacing of the transverse frames is thus reduced to 3½ feet. This system of construction is comparatively simple, and is found to answer remarkably well.

TECHNICAL DRAWING.—LXII.

DRAWING FOR BRICKLAYERS.

PRELIMINARY OBSERVATIONS ON BRICKS GENERALLY.

The principles of brickwork having been treated of and illustrated in "Building Construction," the subject will be further worked out in the present lessons, and an opportunity will be given to the students who have obtained general notions of this branch, of increasing their stock of knowledge, and of entering into details of construction and form, thus acquiring the power of delineating works which have been, or are to be, erected, with intelligence and interest.

The work of the bricklayer and that of the carpenter are intimately combined, and these two form the principal part or carcase of the building; their work is *structural*, whilst that of the joiner, the plasterer, the painter, etc., is secondary, or in some cases ornamental.

In the present mode of finishing dwelling-houses in England, everything excepting the outside walls (and even these are often covered with stucco) is cased up by the joiner, plasterer, and painter, in such a way that the whole of the carpentry as connected with the walls is completely hid. In this series of our lessons, therefore, we shall endeavour, by giving sections, etc., to show the manner in which the woodwork is connected with the brickwork, and to give such illustrations of details of construction which could not otherwise be obtained without visiting buildings in course of erection, and watching the progress of the works from beginning to end—a plan which, where possible, is most desirable and important.

Bricks must be considered as artificial stones, and the use of them seems to date from the earliest period of the history of man. We know that the tower and city of Babel were built of bricks, and that the children of Israel were employed in Egypt not only in making, but in building with them, and the numerous bricks found show us the exact size, form, and quality of those used in these remote times.

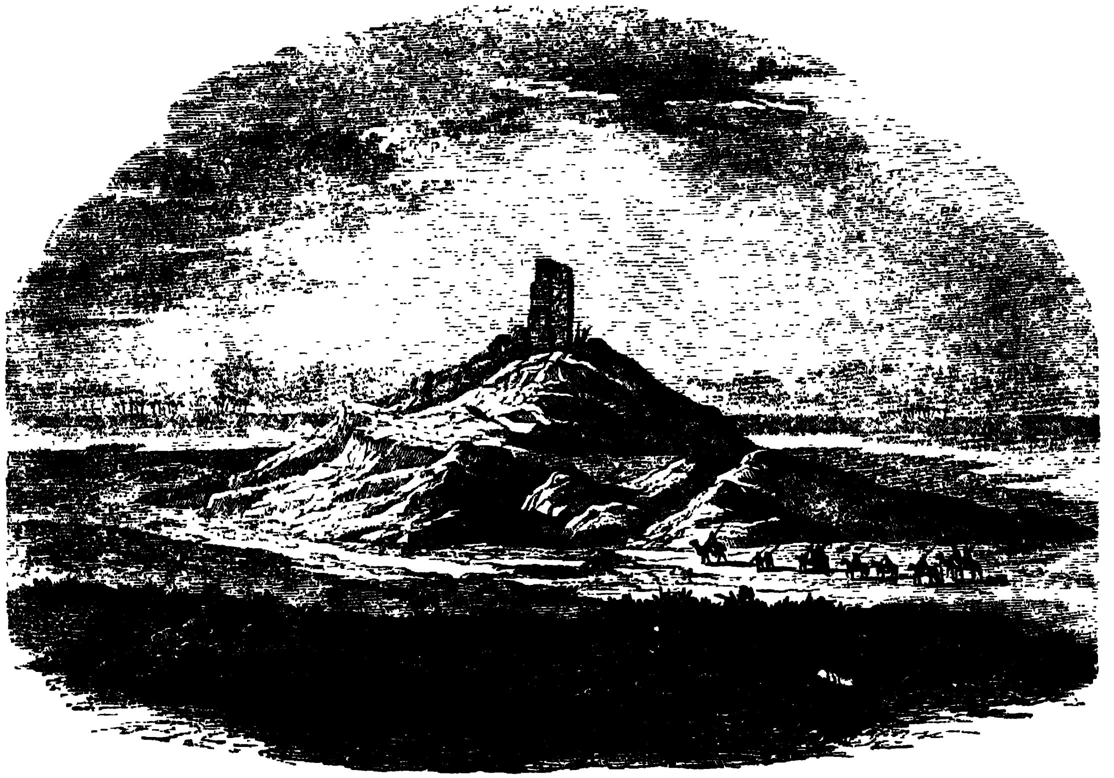


Fig. 520.—PRESENT APPEARANCE OF THE BIRS NIMRUD—SUPPOSED TO BE THE TOWER OF BABEL.

In speaking of the tower of Babel, we may remark that the remains of this early brick structure, possibly the oldest of the kind that is still in existence, are supposed by Sir R. K. Porter and others to form the Birs Nimrud, a mound of irregular shape about six miles from Hillah, on the western bank of the Euphrates. At the top is a solid pile of brickwork about 38 feet high, and 28 feet broad, rent and partially vitrified by the action of fire, while the summit of the mound is strewn with huge vitrified masses, in which the courses of the bricks can be plainly traced.

The Greeks used chiefly three kinds of bricks—the first sort was called "bricks of *two palms*," the second "of *four palms*," and the third "of *five palms*." Besides these they had also bricks of just half the above dimensions, used for making their work more solid, and for giving an agreeable diversity to its appearance.

The Romans began to build with bricks towards the decline of the Republic. According to Pliny, those most in use were a foot and a half long, and a foot broad, which agrees with the dimensions of numerous Roman bricks found in England—namely, about 17 inches in length, by 11 inches in breadth.

The stately columns of Venice were built of bricks, which, according to Sir Henry Wotton, were first formed in a circular mould, and cut, prior to their being burned, into four or more sections. Afterwards in laying, they were so closely and accurately joined, that the column had the appearance of being formed of one entire piece.

For the general purposes of building, bricks have certain advantages over stone—not only as being lighter, but also because their porous texture facilitates their union with mortar, and makes them less liable to attract or retain damp and moisture.

In England, the moulds in which bricks are formed are 10 inches in length by 5 inches in breadth. The bricks when burned are rather less than 9 inches long, 4¼ inches broad, and 2¼ inches thick. The degree of shrinkage, however, is various, according to the purity and temper of the clay, and the intensity of the heat to which it is exposed. In order to avoid double lines to indicate the joints in drawings representing brickwork, the lines are drawn at what would be the middle of the mortar, and the bricks are thus for drawing purposes considered as being 9 inches long, 4½ inches wide, and 2½ inches thick. Paving bricks are 9 inches long, 4½ wide, and 1¾ inches thick.

It is usual to compute thickness of walls by the number of bricks or half-bricks extending across them, in which measurement allowance is also made for the mortar used in the vertical joints. Thus, for example, a

1	brick wall implies one of	9	inches thick.
1½	„ „ „	13½	„ „
2	„ „ „	18	„ „
2½	„ „ „	22½	„ „
3	„ „ „	2ft. 3in.	thick.
3½	„ „ „	2ft. 7½in.	„
4	„ „ „	3ft.	„

Whilst, however, this method is followed in describing the walls of houses and other civil buildings, the dimensions of the revetments of fortresses or other military structures, and substantial masses of brickwork, are always stated in feet.

In the vicinity of London, bricks are commonly burned in clamps; in many parts of the country, however, it is the custom to burn them in kilns, which not only require less fuel and save time, but also turn out the bricks in a more compact condition.

In building the clamps, the bricks are laid after the manner of arches in the kilns, with a vacancy between every two bricks to admit of the action of the fire; but instead of arching, the space for the fuel is made by making the layers project one over the other from each side until they meet at the top.

The flue is about the width of a brick, carried up straight on both sides about three feet; it is then nearly filled with dry bavins or wood, on which is laid a covering of sea-coal and cinders, or *breeze*. The arch is then overspanned, and layers of breeze are strewed over the clamp as well as between the rows of bricks.

When the clamp is about the width of six feet, another flue is made, in every respect similar to the first. This is repeated at every distance of six feet throughout the whole clamp, which, when completed, is surrounded with old bricks, or some of the driest unbaked ones which have been reserved for the purpose. On the top of all, a thick layer of breeze is laid. The wood is then kindled, which gives fire to the coal, and when all is consumed, which will be in about twenty or thirty days if the weather be tolerable, the bricks are concluded to be sufficiently burned.

If the fire in the clamp burns well, the mouths of the flues are stopped with old bricks plastered over with clay. The outside of the whole clamp is also plastered with clay if the weather be precarious; or if the fire burn too furiously and against any side particularly exposed to rain, screens are laid, made of reeds worked into frames six feet high, and sufficiently wide to be moved about with ease.

A kiln is usually about 13 feet long, about 10 feet 6 inches wide, 12 feet in height, and will burn 20,000 bricks at a time. The walls are about 1 foot 2 inches thick, and incline inwards towards the top, so that the area of the upper part is not more than 114 square feet. The bricks are set on flat arches, having holes left between them resembling lattice-work. The bricks being set in the kiln, and covered with pieces of broken bricks or tiles, some wood is put in and kindled, to dry them gradually; this is continued until the bricks are pretty dry, which is known by the smoke turning from a dark to a transparent colour.

The burning then takes place, and is effected by putting in brushwood, furze, heath-fagots, etc., the mouths of the kiln having been previously stopped with pieces of brick, called *shin-log*, piled one upon another, and closed over with wet brick-earth. This shin-log is carried just high enough to leave room sufficient to thrust in a fagot at a time. The fire is then made up, and continued until the arches assume a whitish appearance, and the flames appear through the top of the kiln, upon which the fire is slackened, and the kiln cools by degrees. This process is continued, alternately heating and slackening, until the bricks are thoroughly burned, which is generally in the space of forty-eight hours.

OF THE VARIETIES OF BRICKS.

The bricks most generally used are *marls* or *malms*, *stocks*, and place bricks; but there is little difference in their manufacture. Marls are prepared and tempered with the greatest care; but the construction of the clamp for burning them is similar to that for other bricks, though more caution is required not to overheat them, and to see that the fire burns equally throughout the clamp or kiln.

The finest malms, called *firsts*, are selected as cutting bricks for arches of doorways, windows, and quoins, for which purpose they are rubbed to their proper dimensions and form.

The next best, termed *seconds*, are used for principal fronts when superior work is required. The cleanly, pale yellow colour of malms, added to their smooth texture and durability, give them a pre-eminence over other sorts of bricks. The kind of bricks most used in each county depends, however, principally on the clay found in the immediate locality; thus the white Suffolk may be called a London brick, whilst the red clay in Cheshire yields the red bricks used to so great an extent in that district.

Graystocks are somewhat like the seconds, but of an inferior quality. These may be termed the standard bricks, and although not equal to malms, should possess two qualities—they should be sound in body and pale in colour; in fact, the nearer they approach stone in this respect the better.

Place bricks, sometimes called *peckings*, *sandal*, or *samel* bricks, are such as, from being outside a kiln or clamp, have not been thoroughly burned, and are consequently soft, of a more uneven texture, and of a red colour. There are also *burrs* or *clinker* bricks, such as, from being too violently acted upon by fire, have vitrified in the kiln, and sometimes several are found run together.

Red stocks are made in different parts of the country, and owe their colour to the nature of the clay of which they are formed, which is always tolerably pure. The best sort are used as cutting bricks, and are called *red rubbers*. In old buildings they are frequently to be seen, ground to a fine smooth surface, and set in putty instead of mortar, as ornaments over arches, windows, doorways, etc. Though many very beautiful specimens of red brickwork are to be met with, yet (says Mr. Peter Nicholson) "these bricks can seldom be judiciously used for the fronts of buildings, the colour is much too heavy, and in summer conveys an unpleasant idea of heat to the mind, to which may be added that, as in the fronts of most buildings of any consequence more or less of stonework is introduced, there is something harsh in the contrast between the red bricks and the cold colour of the stone; and even where no stone is employed there is always some wood used, which being often painted white, by no means lessens the objection. Graystocks match so much better with the colour both of stone and paint that they have obtained a universal preference in London and its immediate vicinity." It must, however, be added that villas and suburban residences built of red bricks with stone dressings are in the present day not at all uncommon.

At Hedgerley, a village near Windsor, red bricks about 1½ inches thick, of very firm texture, are made; they will stand the greatest violence of fire, and are called Windsor bricks, and sometimes *fire-bricks*.

Besides the foregoing varieties, the following must be mentioned, although some of them are not often seen now:—1. The ordinary *Paris brick*, which is 8 inches long, 4 inches broad, and 2 inches thick, French measure, which makes them rather larger than ours. 2. *Buttress or plaster bricks*, made with a notch at one end, half the length of the brick, used for binding work built with great bricks. 3. *Capping bricks*, used for the purpose which their name denotes. 4. *Great bricks*, used in fence walls; they are 12 inches long, 6 inches broad, and 3 inches thick. 5. *Cogging bricks*, for making the indented work under the capping of walls built with great bricks. 6. *Compass bricks*, of a circular form, for steyning walls. 7. *Concave bricks*, made flat on one side like an ordinary brick, and hollowed on the other; used for drains and water-courses. 8. *Dutch or Flemish bricks*, used in paving yards, stables, etc.; also for lining soap-boilers' cisterns and vaults. 9. *Feather-edged bricks*, made of the same size with the ordinary statute bricks, but thinner on one edge than on the other; they are used for pinning up brick panels in timber buildings.

Brick and tile paving is performed by the bricklayer. Brick paving is either flat or on edge, in sand, in mortar, or cement. Brick flat paving in sand—that is, with the bricks laid on their broadest surfaces and bedded in and on dry sand—is not to be considered strong or permanent; nor is flat paving in mortar much better, for if the soil on which the bricks are laid be at all light or sandy, they become loose by unequal pressure, water or damp is absorbed by the ground beneath, and the paving yields to the tread; in fact, thin mud sometimes collects underneath, which, as a brick is trodden upon, is pressed upward, and the floor is thus kept in a constantly damp, dirty, and unhealthy condition.

GREAT MANUFACTURES OF LITTLE THINGS.—VII.

LOCKS.

BY CHARLES HIBBS.

REMEMBERING the ponderous machines upon which the artist metal-workers of the Middle Ages used to lavish so much wealth of decoration, it might seem that we are scarcely justified in placing the subject of this article among the "Manufactures of Little Things." But when it is stated that the average yearly production of locks in one district alone is not less than 25,000,000, of which by far the larger part are small till, cabinet, and pad locks, some of the latter being sold wholesale at the ridiculously low price of 2½d. per dozen, it will be seen that they have a fair title to be comprehended in this series. The district alluded to, which is the principal seat of the industry in the kingdom, comprises Wolverhampton, Willenhall, Walsall, Wednesfield, and several smaller towns in what is familiarly known as the "Black Country." Of these, Wolverhampton may claim to rank first, since here are made those qualities which combine scientific construction with high-class workmanship, and which are sold at high prices, varying from a few shillings each to several pounds. Here are the famous works of Messrs. Chubb and Son, whose make was estimated by Mr. J. C. Tildesley in 1866 to be 30,000 per annum, none of which were sold under ten-shillings each. The reputation of Wolverhampton for lock-making is not of yesterday. Dr. Plot, writing in 1686, says quaintly: "The greatest excellency of the blacksmith's profession in this county lies in the making of locks for doores, wherein the artisans of Wolverhampton seem to be preferred to all others. . . . And these locks they make either with brass or iron boxes, so curiously polish't, and the keys so finely wrought, that 'tis not reasonable to think they were ever exceeded unless by Tubal Cain, the inspired artificer in brass and iron." Willenhall, on the other hand, is the chief seat of the *cheap* lock manufacture, and so exceedingly rapid is the process of production, that a Willenhall lockmaker is popularly said never to take the trouble of stooping to pick up a lock which he may happen to let fall, because it would take him less time to make another. The common and simple sorts are certainly put together with great celerity; the various parts being cut out with a press, the holes pierced, and the bright portions polished beforehand, so that they only require to be riveted together with a few taps of a hammer, and the touch of a file is scarcely needed.

Many curious specimens of ancient locksmiths' work still exist, remarkable for what our forefathers used to call the "pretty conceits" of their ornamentation and construction, which we have not the necessary space to describe. We must be content to refer only to such as will serve to illustrate our subject as we proceed. It is thought that the technical student will be most interested in following the various steps or stages of improvement in construction, which have enabled us to supplant the rude, heavy, and eminently unsafe locks of former times, by the complex and beautiful machines that now guard the doors of our merchants' and bankers' safes. There is not much to be said about the methods of manufacture, the skilled hand being the principal instrument used in the production of the better kinds of locks; but there is very much that is interesting in the history of the successive inventions which have been brought out with a view to secure the one desideratum—impregnability—and their defeats in detail by the efforts of the scientific lockpickers. Such mechanical or other contrivances used in the workshops as have novelty, we shall not fail to notice; but our principal object will be to convey to the reader's mind a clear idea of the mechanism of the locks themselves, from the earliest and simplest down to the latest and most intricate. In attempting this, we cannot pretend to do more than touch the main landmarks of the subject; we cannot describe all modifications of detail; but we shall endeavour to make clear the several changes of principle which have been introduced into lock-construction. To do this without diagrams will be difficult, but if the reader will give his attention we hope to succeed.

The ancient Egyptian wooden lock, which guarded the doors of Thebes, and which is in use to this day in Turkey and the East, may serve as a good starting-point for our inquiries. It is more like a bolt than a lock, and we shall best understand its description by keeping in our mind's eye the model of an ordinary door-bolt, working into a staple. The bolt itself was a beam of wood, and the staple was also a huge block of wood, cut away to receive the bolt, a similar block being fixed upon the door, for the bolt to slide in. When the door was closed, and the bolt shot into the cavity of the block that was fixed upon the jamb, the bolt mechanism proper was complete. Now for the locking. In the upper part of the block that was fixed upon the door had been bored, say three, vertical holes, in which lay loosely as many wooden pins, their lower ends resting on the top surface of the bolt. When the bolt was pushed as far as it would go into the staple on the jamb, in order to fasten the door, three corresponding holes, bored in the substance of the bolt itself, came immediately under the loose-lying pins, and they fell in by their own gravity. The bolt was therefore fixed until the pins could be lifted out again. A plate fastened on the top of the block prevented the heads of the pins being seen, or reached, from the outside. It should be understood that the pins were furnished with projecting heads which only allowed them to fall a certain distance. Now for the key. This was also simply a straight bar of wood, with pegs fixed near one extremity, corresponding in number and position to the locking pins. A longitudinal slot cut in the face of the bolt on the side nearest the door admitted this key, it being of sufficient height to allow the projecting pegs to pass. When the key was pushed to the end of the slot, the pegs being immediately under the locking pins in their holes, it was lifted up bodily, and pushed the pins upwards until they came flush with the top of the bolt. Then key and bolt together were drawn back until the fastening was released. So ponderous were some of these "locks," that the key was almost as much as a man could carry, and it was of this kind that the prophet Jeremiah spoke, when he prophesied, "The key of the house of David will I lay upon his shoulder." The reader is requested to bear this description in mind, as he will discover that this primitive device of the ancient Egyptians is the type of the modern tumbler-lock.

It will readily be seen that a door fastening like this, though not devoid of ingenuity, would present no obstacle to a modern house-lifter. Nothing would be easier than to ascertain the position of the pegs by taking an impression of them with a blank bar, properly waxed.

The next stage of improvement was properly the warded lock, about the date of whose introduction there is considerable doubt. Warded keys have been found at Pompeii, and among Roman remains at various places, differing very little in shape from those of the present day. The bolt was no longer of wood, massive and clumsy, but of metal, probably bronze, and of more reasonable proportions. It would also necessarily be enclosed in a box, in order that the wards might be affixed in their proper places and concealed, and so would be [illegible] sufficient resemblance to a modern ordinary warded lock to render a description of the latter sufficient for our purpose. Everybody is familiar with the action of the common back-spring door-lock, in which, by the turning of a key, the bolt shoots backwards or forwards with a jerk and a snap. The solid lump of iron which enters the receptacle on the door-post does not represent the thickness of the bolt throughout; inside the box of the lock it is cut away to a thin strip, and slides within runners fastened to the back plate. Out of the bottom edge of the strip is cut a semi-circular recess, called the talon, in which the key catches, and impels the bolt either way, according to the direction in which it is turned. A spring presses on the top of the bolt, and causes it to grind in its motion upon the edge of a stud, fastened to the back plate, the lower side of the bolt resting upon it at its hinder extremity, behind the talon. Two shallow notches cut in this part of the bolt, and the space between them smoothed and rounded, so that when the key turns in the talon, the bolt is lifted, as it were, out of one notch into the other. This causes the jerking motion that is felt in locking and unlocking the door. The projecting part of the key which works into the talon, and which is called the bitt, or web, of the key, is impeded in its revolution by certain strips of metal attached to the back plate, which render it necessary for corresponding clefts or slots to be made in the bitt, in order to pass them. This constitutes the ward arrangement, which may be as complicated as the artificer pleases. Some of the ancient locks had wards of the most intricate character. Upon the edges of the upright strips, which ran round the lock in the direction of the semi-circular sweep of the key, were fastened cross pieces of various shapes, called bridge-wards, which required perforations to be made in the key resembling an anchor, a star, or some other artistic device. It will be obvious that in the case of a lock which has to be opened from either side, such as that of a street door, there must be wards upon both plates, and also that the wards upon the front plate must be exactly identical with those upon the back plate, or otherwise the key will not be reversible.

The great fault of the warded lock is that it may be very easily picked. Seeing that the only part of the key which really does the work of locking and unlocking is that end of the bitt which impinges upon the talon, it was only necessary to cut away all the middle part to escape the wards altogether. A lock might even be opened with a piece of bent wire, provided it were strong enough to overcome the resistance of the spring. To defeat this in some measure, wards were fixed which required a slit to be made in the *end* of the bitt; and in the case of a non-reversible key, wards of complicated shape were attached to the front plate of the lock, so that the perforations required to be started from both sides, and to run into each other in an intricate pattern that could not well be guessed. But however elaborate the defences, they were always to be overcome by a professional picklock, if only he could snatch an opportunity to take an impression of the wards with a blank key, coated with wax or soap, or even with the smoke of a tallow candle. Having secured this, he could make a skeleton key of the shape required, taking care that it should have a cavity wherever there was a ward to encounter, and the lock was at his mercy. In fact, he had only to carry a sufficient assortment of skeleton keys of different sizes and shapes, Z shape, M shape, etc., to be able to master almost any lock he might have the chance to operate upon.

Many devices were early resorted to for the purpose of increasing the security of the warded lock, such as that of introducing an alarum, etc.; but bolder inventors sought safety in departing from the principle altogether. The most curious example we have of a lock having neither wards nor key, is the letter-padlock, which appears to have been invented about the beginning of the seventeenth century. As it enjoyed a great reputation up to a late date, being used for the fastening of courier's despatch-boxes, coffers containing deeds, etc., where secrecy and inviolability were desiderated, and as it will serve admirably to illustrate a most important point in our present inquiry, it will be convenient here to describe it. In general appearance it resembled a barrel or cylinder, slung horizontally between the two ends of a bow. The bow, or shackle, was hinged at one end to the barrel, and when shut down was secured at its other end by a catch fixed on a spindle which passed into, and fitted, the whole interior length of the barrel. All that was necessary to open the lock was to draw out the spindle sufficiently to release the catch. The problem then was how to prevent any person, not the legitimate user of the lock, from drawing out the spindle. This object was effected by the following ingenious contrivance. On the spindle was a row of studs, set at equal distances in a line. A longitudinal slot in the barrel permitted the entrance of these studs, which were long enough to project through the slot, and to stand up a little above the exterior surface of the barrel. On to the barrel were now slipped a series of stout flat metal rings, each having a transverse groove at one part of its internal periphery, to enable it to pass the still protruding studs. The internal edges of each ring were also stepped or rabbeted all round, so that when all the rings lay [illegible] together on the barrel, these steps, joining, formed a cylindrical groove within which the stud would freely traverse, if the rings were turned round. The rings, therefore, being once passed over the studs, and moved round a little by the fingers, would effectually lock the spindle in the barrel, nor could it be withdrawn until all the rings were restored to that position in which the transverse grooves came together in a line. As the outside of the rings was smooth and even, and as they fitted accurately together, there was nothing to guide the fraudulent tamperer with the lock, as to the situation of the internal grooves, and he might not probably succeed by guess-work in a lifetime in getting them to the opening position. How, then, was the owner himself to manipulate the lock? Round the outer surface of each ring were engraved the letters of the alphabet, and only when the rings were severally turned round so that the letters forming a certain word came into line immediately under the bow would the lock open. These locks were alluded to by Beaumont and Fletcher, in the play of the "Noble Gentleman," and also by the poet Carew, who in one of his verses compares something to—

> "A lock
> That goes with letters, for till all be known,
> The lock's as fast as if you had found none."

The word, which must consist of as many letters as there were rings, might of course be selected by the owner when he ordered his lock from the smith. Thus, if there were six rings, he might choose the word *sesame* as the talisman. Having locked up his treasures, he had only to move the rings round indiscriminately until the letters were thrown into *pie*, and he might rest satisfied that no person ignorant of the magic word would be able to despoil him. But there was a flaw in the security of these early letter-locks, inasmuch as the secret of the opening cipher was at least shared between the owner and the locksmith, and the former might be surprised out of it by a stealthy watcher. A great improvement was introduced, it is said, by Regnier, director of the Musée d'Artillerie at Paris, about the middle of the seventeenth century. He made a lock with a double set of rings, one over the other. The outer rings, by means of movable studs, the position of which could be varied at pleasure, governed the movements of the inner rings, and thus the owner was enabled to set the lock to any combination of letters he pleased, or even to vary the combination from day to day, the secret resting only with himself.

This, slightly modified, is the letter-lock which has come down to our day. Looking to the enormous number of permutations that can be made in the alphabet repeated six or seven times, it might be supposed that the lock was impregnable, except to violence; it would at least seem to defy all the arts of the picker. So, at least, it was supposed, down to the dawn of the era of International Exhibitions. It was during the great world's fair of 1851, as our readers will remember, that the lock controversy, as it has been called, filled the pages of our scientific journals, and set all the mechanicians in the kingdom pondering upon the means of defying the skill of the professional violator. It was then that the celebrated American expert, Mr. Hobbs, made the memorable and alarming declaration, that *all* the locks which had hitherto been made in England admitted of being very easily picked. We have yet to lead up to the history of that famous picking of Bramah's lock, which had been hanging for half a century with a standing challenge to the mechanical genius of all the world, offering a large reward to whoever should open it without injury by any instrument except its own proper key. But to do this, we must thread our way, step by step, through the various improvements that were made in the original warded lock, by the introduction of tumblers, levers, etc., and we must endeavour to master the principle upon which the Bramah lock was constructed. To return to the letter-lock. One of these, of perfect workmanship, and of the most improved construction, was shown to Mr. Hobbs during a visit he was making to a celebrated lock manufactory. Its advantages were being descanted on—its entire independence of a key or other separate instrument—the length of time it would take to put it through its millions of permutations—and the consequent utter impossibility of getting it open by any illegitimate means—short of wrenching or sawing its parts asunder. As the conversation proceeded, Mr. Hobbs was turning the instrument about, apparently in an unconcerned manner, with his fingers, and in a few minutes from the time he first had possession of it, to the great amazement and consternation of those who were sounding its praises, he showed them the lock open in his hand. If a miracle had happened, they could not have been more astonished. From that moment all faith was shaken in the presumed impregnability of the permutating principle.

The manner in which Mr. Hobbs accomplished this feat was as follows:—He first applied pressure to the end of the bolt, or central spindle, in the direction tending to draw it out and release the bow. For the purpose of picking the lock, it is necessary that a continuous pressure should be exerted in this direction, pulling, as it were, against the interior obstacles presented to the withdrawal of the spindle with its studs. To a clever manipulator like Mr. Hobbs, there would be no difficulty in maintaining this gentle pressure with the fingers of one hand, even while curious eyes were watching his movements; under other circumstances a bent spring would best answer the purpose. The spindle being thus acted upon, the interior studs, if the mechanism of the lock were absolutely perfect, would all be pressing equally upon the sides of the rings; but it was at that time practically impossible, even if its importance had been foreseen, which it was not, to make a lock with such extreme accuracy and nicety in its fitting parts as that some of the rings should not bind more than others. Mr. Hobbs then felt cautiously and delicately which of the rings was tightest, by which he knew that one of the studs was pressing against it. He then turned that ring very gently round until he felt the stud slightly jump into the transverse groove. Leaving it carefully there, he felt for the next tightest ring, and repeated the operation, and thus by turns, aided by a most delicate sense of touch, he got the transverse grooves all together in a line, and the spindle came out.

This description, if we have succeeded in making it clear to the reader's mind, will help him to understand the principles of attack and defence, if we may so express it, which are involved in the lock manufacture of the present day. The science of lock-making, at the period we speak of, passed through a phase which very much resembled that now going on in the science of warfare, the alternating triumphs of armour plates and projectiles. As the old locks were found to be unreliable, improvements were introduced, which for a time baffled the skill of the lock-picker; and then he, in his turn, by a new exercise of ingenuity, overcame the difficulties, and became master of the situation again.* We shall endeavour to describe the principles of lock-making and lock-picking with equal minuteness, believing that it is of quite as much importance for us to know the weak points of our defences as the strong ones, and that it is a false policy to hide the knowledge of the vulnerable parts from ourselves, for fear of exposing them to an enemy, who probably knows them too well already. But this must be reserved for a future paper.

FORTIFICATION.—X.

BY AN OFFICER OF THE ROYAL ENGINEERS.

APPLICATION OF FIELD FORTIFICATION TO THE DEFENCE OF EXTENDED POSITIONS, INCLUDING VILLAGES, HOUSES, ETC.

BEFORE examining in detail the ways in which villages, groups of buildings, etc., can be hastily rendered defensible, and the principles on which the work should be done, it will be well to consider for a moment the circumstances under which an army would avail itself of the aid of fortification in the active operation of a campaign. It may safely be asserted that as a rule the defensive force is the less numerous of the two, and that it will endeavour to induce the enemy to fight on some previously prepared battle-field where the natural strength of the position (increased if possible by artificial means) will more than compensate for the numerical disparity between them.

Except under very exceptional circumstances, it will not suffice for the defenders to wait passively behind their defences, lest their position should be turned, and they consequently must often manœuvre in advance of their final position, so as to mask the existence of their own defensive arrangements, and to draw the enemy on to them unawares. The attack, on the other hand, having no fixed plan of operation beyond the strategic considerations of the campaign, will endeavour to force their weaker opponents to fight whenever a favourable opportunity occurs.

When the defenders have time, say two or three days at their disposal, and a strong position to defend which is difficult to turn (as was the case with the Russians at the Alma), it would seem almost criminal not to fortify and improve its natural advantages to the greatest extent. As that length of time is sufficient for the construction of formidable field-works, the nature of the defences need only be dependent on the slopes and character of the ground over which the attack must be made. The Russian position on the heights above the Alma had one flank secure, and the ground was naturally very strong in front, so that there can be little doubt that if it had been thoroughly intrenched, the loss to the Allies would have been much more severe than it was. Such favourable conditions as these, it need hardly be said, rarely occur, and it must often happen that an army is forced to fight with inferior numbers in a position offering considerable advantages to their assailants. In these cases it is that a practical knowledge of field fortification judiciously applied, may turn the scale in its favour, as the defender may so strengthen the points most inviting attack that he can hold in check large masses of the enemy with a comparatively small force, while with the remainder of his troops he is free to act when a favourable moment occurs.

Economy of strength and concentration at the vital points, coupled with the power of taking up the offensive at pleasure, are the principles on which the defence should be arranged.

The defending force has the advantage of being in possession of the ground on which the fight is to take place, and consequently can accurately determine its defensive capabilities. They cannot expect, however, in a very limited time to thoroughly fortify their whole line, and even if they could the attack would probably avoid a direct advance, and would assault in another direction a few hours later, for it is one of the great advantages possessed by the assailants that they are free to attack wherever they can find a weak point, whereas the defenders are more or less obliged to adhere to their works, unless they fight in the open at a numerical disadvantage.

The real difficulty of the defender, therefore, is to foresee the probable phases of the, as yet, undeveloped fight, and then to determine what points most require to be strengthened, and how far it is possible to do so in the time.

The best way of solving the difficulty would appear: firstly, to carefully ascertain the strength of your position as regards materials, labour, etc., for defensive purposes; secondly, to curtail the extent of front occupied to as great an extent as possible, so as to have a powerful reserve in hand after garrisoning the various points occupied; and thirdly, having generally sketched out your plan, endeavour if possible to examine your position from the enemy's point of view, by riding forward on to the ground on which his guns will probably be placed, and then consider how in his place you would best be able to attack it.

By this means many weaknesses and defects in your original scheme will be detected, and you will be able to notice the hollow ground and other spots where he will probably assemble the masses of his troops before making his assault. The position of these points being known and indicated, their distance should be ascertained from the intended position of your guns. Having now matured your plan, use every exertion to strengthen the principal points of your position, and to clear away round each anything likely to obstruct your fire, working outwards in every case. Endeavour to provide easy means of communication between one part of the line and another, and especially facilitate the movement of the reserve towards the threatened points. Theoretically an obstinate successive defence from house to house should be arranged, finally culminating at some large building where the reserves and remnants of the garrison may make a final stand. This, however, applies more to villages held as isolated posts than to those forming part of a general position, and, moreover, it cannot often happen that there is sufficient time for such complete arrangements. In any case it is obvious that it is of primary importance above all things to render it impossible for the enemy to get even a temporary possession of your outer line, for when their troops have once obtained a footing in houses, and behind walls, hedges, etc., the original conditions of the fight are reversed, and it becomes a serious and difficult matter to dislodge them.

A good accumulation of obstacles in front and round the points to be rendered especially strong, supplemented by the steady fire of infantry armed with breech-loaders, should render it almost impossible to force such positions, even with overwhelming numbers, unless the attack has been preceded by a heavy and accurate artillery fire. The advantages of the attack are doubtless very great, and some recent German writers hold that the defenders will be so demoralised by their necessarily passive attitude under a crushing artillery fire, that an assault in force must succeed. The results of the last war (1870), however, seem to point to an opposite conclusion, as the German lines of investment round Metz and Paris (consisting of villages in a state of defence) were never forced, although attacked on several occasions by large bodies of troops and a powerful artillery.

The distance between the strong points in the line should not be too great to prevent the intervening space being thoroughly defended by a cross-fire of musketry and mitrailleuses, and the guns of the defence should be placed well in rear of the front line, so as to be out of danger of immediate capture, and in such positions that while they can defend the front and intervals between the fortified points in the line, they do not draw the fire directed against them on to the houses occupied by the infantry.

The plan of concentrating your force for the defence of certain spots has the defect that the enemy will concentrate his artillery on some of them, and endeavour to crush your defences and form a gap for the entrance of his assaulting columns, who would remain under the nearest cover until there appeared to be a chance of success; it must be remembered, however, that he would probably adopt exactly the same line of action in any case, and that if you can only manage to place your men under cover close at hand, and so diminish the casualties, you are in a far better position to repel an assault than if you had originally adopted a more scattered distribution of your force.

The effect of field artillery on ordinary farm and cottage buildings appears to be various, depending as it must on the nature of the masonry, and on whether time or percussion fuzes are used for the shells. Much valuable information has doubtless been obtained on this head during the late war in France, which is not yet published. It would seem, however, most certainly advisable to loophole and prepare for defence all buildings, walls, etc., to the fullest extent, trusting to be able to make use of some of them when the storm of shot and shell is over. Care should be taken that all means of forming banquettes on the outside are removed, and that the loopholes are at such levels as to be useless except from your own side of them. As, however, buildings that have evidently been loopholed, etc., would inevitably draw a large portion of the enemy's artillery fire preparatory to the assault, it would seem unadvisable to garrison them with more than a few picked marksmen, and a sufficient guard to extinguish the fires that are nearly sure to break out under a heavy shell fire.

The infantry should be posted under cover in a trench, or behind cover of some kind, a short distance in advance of the buildings, the ruins of which they will eventually have to defend. They are then on the spot and ready for instant action, but should lie down or be kept out of sight during the preliminary artillery duel, and until the enemy's infantry get within range.

They may be further protected from splinters of shells and stones, brickwork, etc., by a mound in rear of the trenches in which they are placed, which latter, however, must not be so deep as to give cover to the enemy if he reaches them. Every possible precaution must be taken against fire by the removal of thatched roofs and other inflammable materials, and by arranging supplies of water in buckets, etc., in each house or room. Where fire-engines are available they should be in readiness at some central point, and arrangements made for their water supply.

Ample reserves of ammunition must be provided in some convenient situation as secure as possible from fire, and yet stowed in such a way as to be capable of being readily moved in cases of conflagration. Communications or rough openings should be made from house to house, so as to facilitate the removal of the wounded and the bringing up reserves without the necessity of their appearing in large bodies in the streets, some of which are sure to be enfiladed. It has been very truly remarked by a recent German writer (Capt. Laymann) that one of the points in which the attack possesses the greatest moral advantage over the defence is the fact that whereas the former are constantly advancing, and consequently leave their dead and hind, the defenders have to stand their ground and the fight amid the depressing influences of having their dead and wounded comrades round them.

To obviate this, organise as far as possible a regular service of stretchers, shutters, etc., with attendants, for each part of the line, so that the wounded may at once be moved, if not to a place of safety, at all events away from positions in which they can only tend to demoralise and increase the difficulties of those that remain at their posts. An efficient system of signals by day and night should be established, and the defenders of each post should clearly understand the following points: firstly, where they are to find their supports and reserves; secondly, where their ammunition reserves are; and thirdly, if forced to retreat, in what direction they are to retire. As the result of the action will depend on the successes at several of these points, this last instruction may have to be modified to suit the changes of the fight, and can therefore only be laid down in a general sense.

In wooded countries it will be essential to cut down considerable numbers of trees, to enable the defenders' guns to sweep the approaches to the position. This is a heavy work in itself, and requires not only numbers of men, but what are probably more difficult to find, large numbers of felling axes and other tools.

In cutting trees to serve as abatis, care should be taken that the trees are cut so as to fall in the required direction, and thus save the labour of moving them afterwards. There is perhaps no more impassable and therefore useful obstacle than a thick abatis of large trees, but the difficulty of getting them rapidly brought to the spot is excessive, as will be seen if we remember that to cut trees down rapidly they must be felled some three or four feet above the ground, leaving a stump of that height. After a few trees have been cut in a wood, it would be impossible to drag others past these stumps unless regular roadways are cleared. When trees are growing near buildings, and are not sufficient to form abatis, it will be better not to cut them down if they do not impede the fire of the defenders, as they serve as a screen from the enemy's view, and shells fired with percussion fuzes would burst on striking their branches.

It is of course impossible to do more than indicate generally what should be done. All the methods of forming obstacles, loopholes, trenches, etc. etc., that have been previously described, would now be applied in a rough, hasty fashion, to meet the circumstances of each case.

They should not, however, be applied along the whole line, but rather be multiplied to increase the strength of certain points only. This will enable the defenders to hold them with less troops, and leave open spaces through which, with their remaining forces and cavalry, they may advance. These spaces, though apparently open, would really be almost impassable for the enemy under a cross-fire of musketry and a direct artillery defence from the guns placed in rear of the line. The foregoing remarks apply to the case of villages held defensively by troops who have been in possession of them for at least a few hours, and when each village is part of a general line and is supported by troops, guns, etc., in rear. We must next consider them as isolated posts, and in what way they may be utilised if seized by troops for offensive purposes in an action.

PHOTOGRAPHY.—VII.

By J. C. Leake.

PRINTING (*continued*).

Having in our last article described the ordinary process of photographic printing, we may now proceed to describe such modifications thereof as are necessary in certain cases. Although the delicate and very smooth surface imparted to the paper by the application of albumen is most useful in securing very fine definition, the gloss which is at the same time obtained is often objectionable, especially in large pictures, and for certain subjects, such as the reproduction of engravings, books, or manuscripts. It therefore becomes necessary to make use of a process in which these defects may be avoided, and this we may now proceed to describe in detail.

One of the simplest and easiest methods of producing a plain paper print is to sensitise the reverse side or back of the ordinary albumenised paper; the whole of the subsequent processes being precisely similar to those already suggested for printing upon albumen. Excellent prints may, however, be produced upon paper which has been simply salted, and this is of course the readiest and most effective method, as well as the cheapest. In order to prepare paper for this process, a dish of glass or porcelain should be provided of sufficient size to hold the sheet, and at least three inches deep. A quantity of the following solution should then be prepared: Chloride of ammonium, five grains; distilled water, one ounce; dissolve, and filter into the dish for use. A sufficient number of sheets having been cut to the required dimensions, one of them should be laid upon the solution, and completely and carefully immersed by means of a glass rod. This operation may be continued until the whole of the sheets—or at least twelve—are inserted. The papers should then be turned over in a mass, and the first inserted sheet removed and suspended by one corner until dry. In some cases gelatine or arrow-root is employed in order to improve the colour, and add to the depth and richness of the impression, without imparting any gloss to the surface of the paper. Of these two substances arrow-root is unquestionably the best; and for many purposes paper prepared with it is exceedingly useful.

The mode of preparing arrow-root paper is as follows:—Take half an ounce of fine arrow-root, and mix with cold water into a cream. Prepare the following solution: Distilled water, twenty ounces; chloride of ammonium, five drachms; dissolve, and boil; adding the arrow-root by degrees and with constant stirring. When cold, the mixture must be skimmed, and the clean paste will be ready for use. The boiling must be effected in a vessel of glass or porcelain, metal being inadmissible. The sheets are to be covered with the paste in the following manner: Prepare a smooth board about half an inch smaller each way than the required sheets of paper. Lay the paper upon this board, and secure it at the edges by means of drawing-pins. The sheet may then be covered with the arrow-root paste by means of a soft sponge, exercising the greatest care in the removal of all streaks and lumps, and in obtaining a perfectly even layer over the whole surface. The paper should then be perfectly dried, when it will be ready for the sensitising process. In the case both of the plain paper, and of that prepared as above described, a strong sensitising bath is necessary where the richest tones are required. From sixty to eighty grains of silver to the ounce of water will generally answer, but the increase to ninety or a hundred will be amply repaid by the increased depth and brilliancy of the resulting proofs. The toning and fixing of the print upon plain or arrow-root paper may be conducted precisely as we have already described for that which has been albumenised, except that in most cases the toning has not to be carried so far, from the fact that the impression is not nearly so red when removed from the printing-frame. It will mostly be found that the prints upon plain paper are considerably reduced in depth in the process of toning and fixing, and they should consequently be printed rather more than would be required if albumenised paper were employed. Either plain or arrow-root paper should be used within twelve hours of its being sensitised.

Although the processes just described are thoroughly reliable and easily worked, it will most probably happen that the tyro will, at one stage or another of his work, meet with certain failures arising from various causes, which we will now consider. One of the most common failures is that of imperfect toning of the proof—either in parts or altogether. Uneven toning may arise either from the partial adhesion of the proofs to each other, or from an uneven coating of albumen. Unless the paper be well albumenised, and the coating perfectly even, it will be difficult, if not impossible, to get prints of even and regular colour; and this is especially the case when very highly albumenised paper is employed. Of course the only remedy here is to employ another sample, although with careful treatment the evil may be reduced to a minimum. Paper at all liable to streak should be toned slowly, and in a solution which has been mixed some days before use. It should also be sensitised upon a strong solution of silver, and used as soon as dry. Of course, in the case of irregular toning through the partial adhesion of the prints while in the solution, the remedy is obvious; and as the evil is much more likely to occur when the bath is freshly mixed, and in its most active condition, the greatest care and diligence should be given to keep the prints constantly in motion while the operation of toning is in course of being effected. It will but rarely happen that the print refuses to tone altogether, but should this be the case it will indicate either that the quantity of silver is considerably reduced, that the paper is very bad indeed, or that the gold toning solution is out of order or too weak. Marbled and spotty prints are sometimes produced from imperfect albumenising of the paper, but much more frequently from an insufficient quantity of silver in the nitrate bath. The strength of this solution is very rapidly reduced, and frequent testing should be resorted to in order to ascertain the amount of silver abstracted, in order that it may be constantly replenished and brought to the standard strength.

The weakness of the silver solution is also a frequent cause of weak flat prints, which upon immersion in the fixing bath of hyposulphite of soda dissolve nearly out, and upon drying present a faded appearance. If the negative be of good quality, the edges of the paper which are not covered by the glass will most probably become bronzed during the exposure necessary to produce a vigorous impression. Should it be observed that this bronzing is difficult to produce, or cannot be obtained by any amount of exposure, it may be safely concluded that there is an insufficient quantity of silver present, and that it must be increased. If the paper be kept a long time between the sensitising and exposure, the silver will combine with the organic matter present, and produce the same result. From the same cause—namely, the keeping of the paper after sensitising—will arise a yellowness of the light parts of the proof, a defect which may also be produced by the use of a toning bath which has become intermixed with that used for fixing, or of a hyposulphite bath which has been used for fixing too large a number of prints. Want of proper definition or sharpness in parts of the picture is frequently produced from the insertion of the paper in an overdry condition. After drying the sheets should be allowed to hang for half an hour at least in the dark room before being placed upon the negative.

In concluding this part of our subject, we may briefly recapitulate the essential rules for successful printing. In the first place, never use any paper but that of the first quality. Secondly, be exceedingly careful that the silver solution is of full strength, and perfectly clean and clear. Thirdly, be careful to remove the whole of the free nitrate of silver before proceeding to tone the proofs. And finally, use fresh hyposulphite for each batch of prints. It is also important that the operations of sensitising, printing, toning, and fixing should be performed as quickly in succession as may be, if possible the same day. If these precautions be adopted, there will be no difficulty in ensuring the most satisfactory results, both with regard to the appearance of the prints and their permanence.

FARMING AND FARMING ECONOMY.—XII.

By Professor WRIGHTSON, Royal Agricultural College, Cirencester.

LIVE STOCK.

INTRODUCTORY REMARKS—HORSES—VARIETIES OF—GENERAL AND SPECIAL MANAGEMENT OF—COST OF, PER ANNUM AND PER ACRE.

WE now approach a most interesting part of our subject. Britain is unrivalled both in the rich diversity and high quality of her live stock. Her cattle, sheep, pigs, and horses are sought for in every civilised country, and the keen competition thus engendered has raised the prices of the best-bred animals to almost fabulous sums. In the summer of 1870 two heifers left our shores for Canada, having been purchased for the enormous sum of 2,500 guineas, and in November last (1871) their two calves were imported from Canada by a Scotch nobleman, Lord Dunmore, for the same sum as had been given for their dams. Even higher prices are given in America and New Zealand for the best strains of English blood, and we are at a loss whether to look upon the keenness of the competition as the result of a "fancy," or to allow the intrinsic value of the purchase to be thus correctly gauged.

Great Britain has always been rich in her many breeds of stock. In the latter quarter of the last century attention was directed towards their improvement, and simultaneously we find Bakewell bringing out his new Leicester sheep, long-horn cattle, and heavy horses; the Collings, Booths, Maynards, and others cultivating the form and aptitudes of the Durhams or Shorthorns; Weyman, Tully, Hewer, and Westcar working upon the Herefords; Ellman improving the South-down sheep; M'Neil taking in hand his West Highlanders in the remote Hebrides; and Quartly and Davy promoting the North Devon cattle.

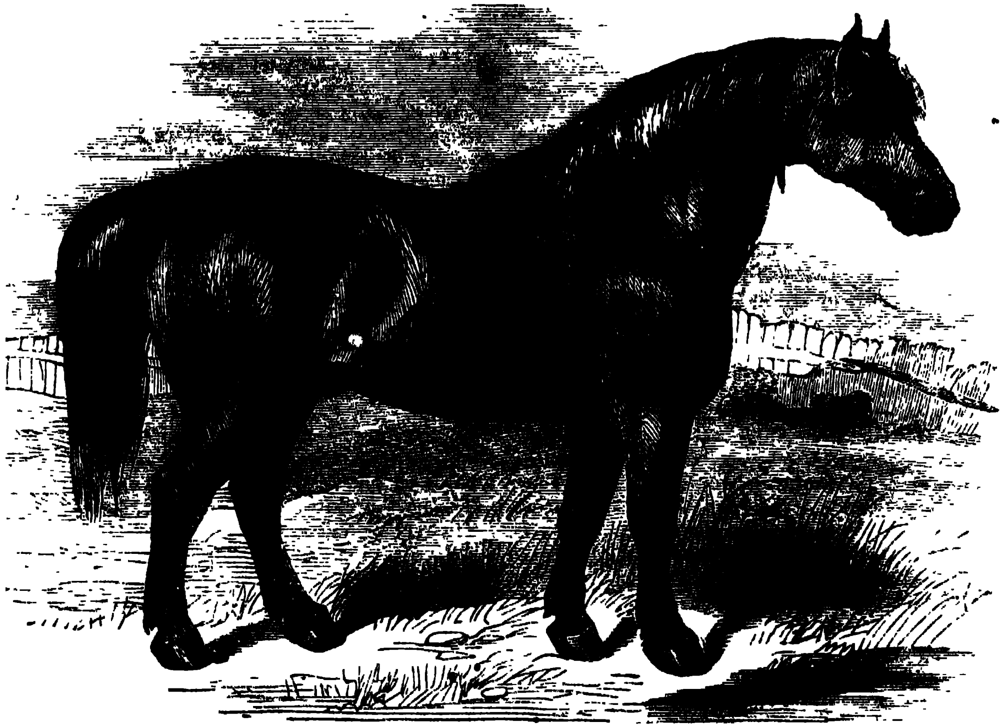
Every recognised breed is an improved one, representing an expenditure of patience, skill, and capital rarely equalled. The pedigrees of pure-bred animals are kept with the greatest care, and the breeders of Shorthorns, Herefords, Devons, Sussex, and Polled Angus cattle, each have their herd-book. If we examine the exhibition catalogues of the Royal and Highland Agricultural Societies, we find prizes offered for ten breeds of cattle, twelve breeds of sheep, and four breeds of pigs, and besides these there are many other varieties of less general interest, but much appreciated in their own localities. There are also some excellent crossed breeds. A proper knowledge of live stock requires us to study the best means of breeding, rearing, and fattening animals, and it is to these parts of the subject that our attention will be chiefly directed. Our standpoint must be that of the breeder, the grazier, and the butcher.

When we study horses it will be with reference to their working powers, and the best way of economising and developing them; the best methods of feeding and management, and the cost of their maintenance. Cattle will be considered as producers of beef and milk; sheep as growers of wool and mutton; pigs as manufacturers of pork.

PRINCIPAL BREEDS OF HORSES.

First let us take a rapid glance at the four principal breeds of agricultural horses.

The *Suffolk Punch* possesses a better combination of strength, compactness, and activity than any other breed. Height at shoulders 15 to 15½ hands; frame characteristically compact; barrel, round; colour, uniformly chestnut, though sometimes sorrel; said to be rather more liable to strains of the sinews and ligaments than other breeds. (Spooner.) Youatt informs us that this breed originated in a cross between the Norman stallion and Suffolk mare; that "the true Suffolk, like the true Cleveland, is now nearly extinct;" and that the present breed "is a cross with the Yorkshire half or three-fourths bred."



THE SUFFOLK PUNCH.

The *Clydesdale*, says Youatt, "owes its origin to one of the Dukes of Hamilton, who crossed some of his Lanark mares with stallions which he had brought over from Flanders."

Spooner informs us that they stand about 16 hands high, are extremely active, and very fast walkers, and that their faults are a tendency to lightness of body, and too great length of legs. A pair of Clydesdale horses will plough a larger breadth of land than any other kind of horse, but they require to be well fed. (Spooner.) The colour is black, grey, or brown.

The *Heavy Black Horse* is chiefly bred upon the rich pastures of Lincolnshire, and the Midland counties. At two years old many of them are purchased by Surrey and Berkshire farmers, who work them moderately, and sell them at four years old for the London market. They are fine-looking animals, and are purchased for show by wealthy brewers, who vie with each other in the magnificence of their teams. The colour is not restricted to black, but varies to grey and brown. The largest specimens of this breed are used for dray-horses. The next in size are sold as wagon-horses, and a smaller variety, with more blood, is used for mounting a considerable part of our cavalry, and also for drawing hearses. (Youatt.)

The *Cleveland Bay* is found principally in Lincolnshire, Yorkshire, Durham, and Northumberland, and is there used occasionally for agricultural purposes. The pure breed is, however, seldom seen, it having been crossed with three-fourths and thorough-bred sires for the purpose of breeding coach-horses. As the name implies, these animals are bay, with black points, and free from long hair at the fetlocks.

A large proportion of the horses used in agriculture are not of any pure breed, but of more or less mongrel character. We would recommend horses of medium size, from 15 to 16 hands high, active, and with a "dash of blood," as best adapted for ordinary farm-work.

The subject of breeding horses, although interesting and important, we must dismiss with few words. As in the case of breeding other descriptions of live stock, the pedigree, parentage, and the pasturage must all be considered. A good line of blood, parents faultless in form and faculties, in prime of life, and free from disease; pastures calculated to develop the good qualities transmitted, are all equally important conditions, and when they are observed, risk of failure is reduced to a minimum.

MANAGEMENT OF HORSES.

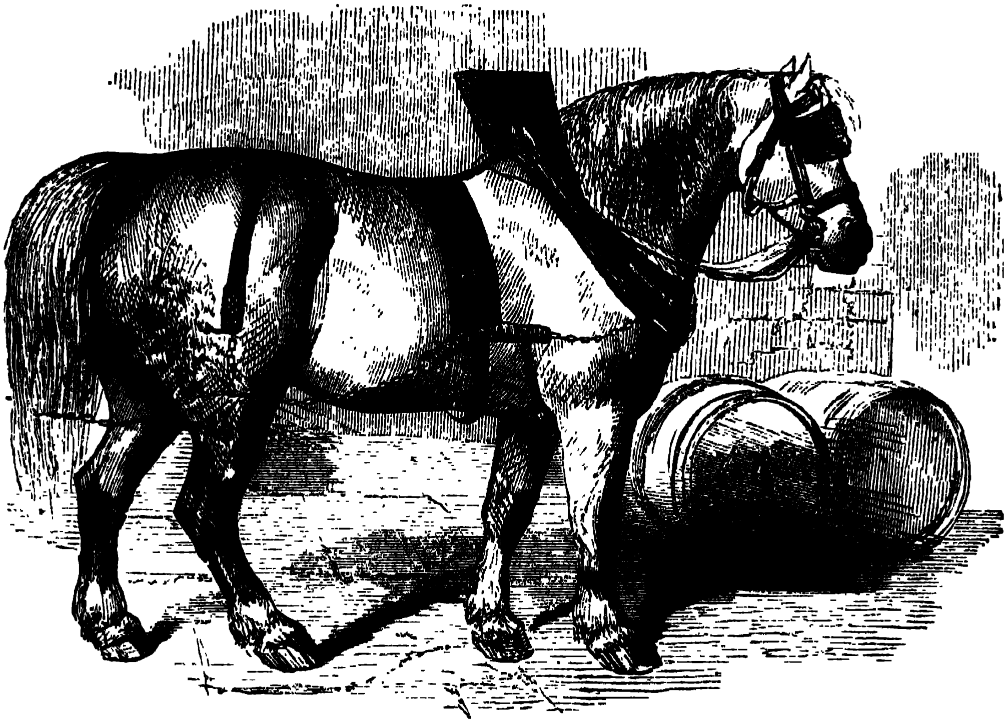
The health of farm-horses greatly depends upon their management. They must be provided with stabling affording sufficient warmth and shelter; they must be properly shod; cleanliness must be enforced; the horses must be thoroughly dressed down night and morning; food and water must be supplied regularly, in proper quantities and at proper times; and the importance of air and proper temperature must not be lost sight of.

The special management principally involves a correct system of feeding. The amount and character of the food given varies with the season and the work in which the horses are engaged. The agricultural year is divided as follows:—first, from the end of harvest to the beginning of winter; second, winter; third, spring and early summer, terminating with the sowing of turnips; fourth, hay and corn harvest. In the first and third periods the horses are constantly employed in work of an arduous character, such as autumn cultivation of fallows, wheat sowing, and afterwards spring corn sowing, and preparing for root-crops.

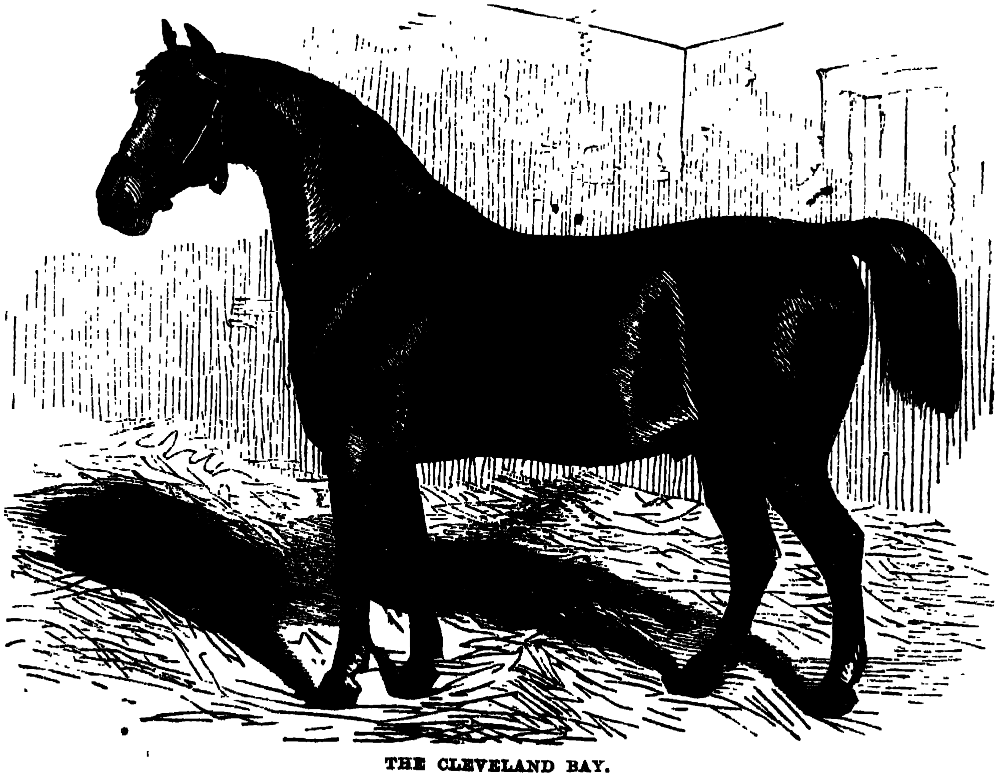
At such times the feed must be liberal, and 2 bushels of oats, half a bushel of beans, and 100 lb. of hay per week, will be an ample allowance.

Mr. Morton has collected, in his edition of Arthur Young's

"Farmer's Calendar," a large number of dietaries employed by well-known agriculturists. From among these we select the following amounts per week:—168 lb. hay, 63 lb. oats, 33½ lb. beans (W. Gater, Botley); 112 lb. hay, 84 lb. oats, 224 lb. beans (W. C. Spooner); hay *ad lib.*, 84 lb. oats, 10 lb. beans, straw *ad lib.*, and ½ bushel of bran (A. Ruston); 168 lb. hay, 70 lb. oats, 14½ lb. beans, 24 lb. bran (A. Simpson, Beauly).



GREY VARIETY OF THE HEAVY BLACK HORSE, OR DRAY-HORSE.



THE CLEVELAND BAY.

After wheat-sowing and throughout winter the amount of corn may be reduced, and a few swedes or mangels and straw-chaff may be given. The following weekly allowance of food in actual use at this season may be added:—112 lb. hay, 52 lb. oats, 70 lb. swedes, and 2 bushels of straw-chaff (S. Druce); hay *ad lib.*, 52 lb. oats, 17 lb. beans, 84 lb. swedes, straw-chaff *ad lib.* (C. Howard); 49 lb. of hay-chaff, 70 lb. oats, 210 lb. mangel, and straw-chaff *ad lib.* (J. J. Mechi).

In the spring, a similar amount of food as that supplied in the autumn is given. In summer, the principal modification consists in introducing cut clover, vetches, etc., or in turning the horses out to grass. Under these conditions horses often lose their relish for corn, and in most cases the amount is reduced. From 1 to 2 bushels of oats (40 to 80 lb.) and cut green food *ad libitum*, are quantities given by good agriculturists.

Scarcely less important than the quantity of food, is the method of feeding. Three systems, each with modifications, include the various plans recommended:—first, feeding with unbruised and uncooked corn, and unchaffed hay; second, manger feeding, in which the hay and straw are chaffed and mixed with the corn, all being given in the manger; third, cooking food. The first of these is the oldest and most general; the second is less fatiguing for the horse, and has been found truly economical; the third is of doubtful merit, but is strongly believed in by many persons.

Lord Londonderry was one of the first who adopted manger feeding, and the result of his experience is thus given by Mr. Caird in his "English Agriculture in 1850-1." "Previous to the introduction of this plan, the ordinary feed for pit-horses was 3 bushels of oats, and 12 stones (168 lb.) of hay per week, and for wagon-horses 3½ bushels of oats and 14 stones of hay. After chaffing was employed, 2 bushels of oats and 7 stones of hay was found sufficient for the pit-horses, and 2½ bushels of oats and with 8 stones of hay for the wagon-horses." Upon the Royal Agricultural College Farm, Cirencester, the system of feeding is as follows:—All food given in the manger; no hay supplied; horses fed three times a day, namely, from 4 to 6 a.m., 11 to 1 p.m., and 5.30 to 7 p.m., and they are watered half an hour after coming in from work. The year is divided into two portions, the first from Michaelmas to May, the second from May to Michaelmas. During the first or winter half, they receive 1¼ bushel of oats, ¼ bushel of beans, 1 bushel of brewers' grains, and about 21 lb. per day of straw chaff (chop). During the summer half they have 1 bushel of oats, ¼ bushel of beans, and green food *ad lib.*

COST OF MAINTENANCE AND OF HORSE-LABOUR PER ACRE.

The cost of maintaining a farm-horse has been frequently estimated as about £30 per annum. Taking the average of 13 cases recorded by Mr. Morton, the cost for food alone per week appears to be 9s. in spring and summer, and 9s. 6d. in winter, or £24 1s. per annum. Assuming these figures as fairly representing this important item, we must add the following as entailed in the maintenance of farm-horses:—

	£	s.	d.
Cost of food	24	1	0
Shoeing	0	13	0
Repairing and furnishing gears . .	1	5	0
Interest on a capital of £30 at 5 per cent.	1	10	0
Deterioration and risk at 10 per cent.	3	0	0
	£30	9	0

Some writers in estimating the cost of maintaining a farm-horse include the cost of keeping up the necessary implements, and the wages of the teamsmen. We, however, prefer to debit the horse with what immediately concerns him, and to open separate accounts for manual labour and implements.

Having ascertained the cost per annum, the next point of interest is the cost per acre, from which we may deduce the proportion of the farmer's capital invested in work-horses.

The number of horses required to work a given area of land will vary according to the proportion of arable to pasture land, the rotation of crops followed; the tenacity of the soil; the extra assistance derived from steam; the distance from markets and railways. Horse-labour on pasture-land is so small that we may leave it out of our calculation. The rotation followed is at once seen to be important, especially if it involves land remaining two or three years under grass. It is, therefore, usual to speak only of the number of acres of fallow land a team is capable of working, and not of the entire number of acres of arable land it can cultivate. Thus, it would be more correct to speak of a pair of horses being able to work fifteen acres of fallow than sixty acres of arable land. They will work the fifteen acres of fallow and carry on the work upon the other sections of the farm without difficulty. In other words, if the farmer has a sufficient force of horses to work his fallow and root land, he will find no difficulty in dealing with his corn and other crops. The following table will best illustrate the application of this principle, and at the same time show the number of horses found necessary upon some well-known farms of very different character.

TABLE SHOWING THE NUMBER OF HORSES EMPLOYED TO WORK FARMS OF VARIOUS CHARACTER IN DIFFERENT COUNTIES.

Farm and Locality.	Quality of Soil.	No. of Acres of Arable Land.	No. of Horses kept.	Acres in Roots or Fallow.	No. of Ac. of Fallow worked by each Pair of Horses.	Remarks.
Royal Agricultural College Farm, Cirencester	Light, brashy, and stronger loams	431	10	100	20	Occasionally employs steam cultivation.
Home Farm, Holkham Park	Light, sandy	1300	42	325	13⅔	32 horses and 20 bullocks, 2 bullocks considered = to 1 horse.
Paston, Northumberland	Dry turnip soil	500	16	100	12½	Northumberland 5-course.
Leyfields, Notts.	Stiff clay	230	9	43	9½	
Bainess, Catterick, Yorkshire . .	Friable turnip soil and some stronger land . . .	381	12	95	15⅚	
Farningham, Kent (R. Russell) . .	Clay	1600	66	400	12	4-horse land, Howard's ploughs.
1st Prize Farm, 1871. Mr. Forester (Sherlow Farm, Shropshire) . . .	Moderately friable . . .	300	9	75	16½	
2nd Prize Farm, 1871. Mr. Winterton (Alrewas, Hays, Lichfield) . .	Moderately friable . . .	408	11	100	18⅕	Occasionally employs steam.
Holderness, Yorkshire (Caird's "English Agriculture," p. 302) . . .	Stiff land and bare fallow . .	400	13	66	10	6-course rotation.
Wittering, North Hants	Very light	480	12	120	20	
		5958	200	1388	14·24	

The average number of acres of fallow worked by a pair of horses in the above table is 14·24, and the amount of arable land 60·30. In order, then, to come to a conclusion as to the cost of horse-labour per acre, we have merely to divide the cost of maintaining a team, by the number of acres it is able to work. Thus, in the average of the above cases,

$$\frac{\pounds 60}{60{\cdot}3 \text{ acres}} = \pounds 1 \text{ per acre.}$$

There are extremes as well as a mean. Accordingly we find in the case of Mr. Parkinson's farm at Leyfields 1 pair of horses only able to prepare 9½ acres of fallow, and 51 acres of arable land, while Mr. Sharpley of Wittering was able to work 20 acres of fallow and 80 acres of arable land with the same power. In the first case we have the cost of horse-labour thus represented:—

$$\frac{\pounds 60}{51 \text{ acres}} = \pounds 1 \text{ 3s. 7d. per acre.}$$

And in the second case—

$$\frac{\pounds 60}{80 \text{ acres}} = \pounds 0 \text{ 15s. 0d. per acre.}$$

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXIV.—JOHN NAPIER, MATHEMATICIAN.

BY JAMES GRANT.

JOHN NAPIER, Baron of Merchiston, the celebrated inventor of the logarithms, the greatest boon perhaps which genius could bestow upon a maritime empire, was born in 1550, during the reign of Mary, Queen of Scots, in the old castle of Merchiston, then situated on a solitary moorland near Edinburgh, but now incorporated in one of the suburban streets of the city. He was the ancestor of all those Napiers who in our own time have been so distinguished by land and sea, and was descended from an ancient family that had long been settled in the shire of Dumbarton, where they held lands under King Robert I. John, the inventor, was the eldest son of Sir Alexander Napier of Merchiston, afterwards Master of the Mint to James VI., by his first wife, the daughter of Sir Francis Bothwell, a Lord of Session; and, singular to say, at the time of his birth his father was barely sixteen years old. Though styled *Baron*, Napier was merely the laird or proprietor of Merchiston, as in Scotland men of that class sat in Parliament under the denomination of lesser barons.

He was educated at St. Salvator's College, in the city of St. Andrews, where he matriculated as a student in 1562. He afterwards spent several years travelling in France, the Low Countries, and in Italy, where a Doge of Venice presented him with the gold filagree box, in which, after his execution in 1650, the heart of the Marquis of Montrose was enclosed.

In the *Proceedings of the Royal Asiatic Society* for 1835 it was stated that "it appeared by the papers of John Napier, the mathematician, that he had, from the information obtained during his travels, adopted the opinion that *numerals* had first been discovered by the College of Madura, and that they had been introduced from India by the Arabs into Spain and other parts of Europe;" but it is unfortunate that the papers containing this fact so interesting to science perished by fire ere they could be printed.

On his return to Scotland in 1571, though a civil war was raging, he applied himself closely to the study of mathematics, and it is conjectured that he acquired a taste for this branch of learning during his residence abroad, more particularly in Italy, where at that period there were many mathematicians of high reputation; and though his solitary tower on the moor was often attacked, taken and retaken by the king's men and queen's men in succession, and more than once cannonaded, he had therein his study, which is still extant; and there (like Bacon, Schwartz, Galileo and others), "he had his little laboratory, his little forge, his crucible and phials, acids and essences, all the rudiments of science, with some faint foreshadowings of his noblest discoveries."

The age and the country were prone to superstition, so Napier speedily won the then unenviable and perilous reputation of being addicted to sorcery. He certainly believed in the discovery of hidden treasure by the use of a divining rod, and there is still in existence a contract drawn up between him and Sir Robert Logan of Restalrig (the famous Gowrie conspirator), concerning a search to be made for gold supposed to be "in the said Robert's dwelling-place of Fastcastell, hid and hoardit up secretlie, quilk as yet is unfound by ony man." For the discovery of this treasure Napier was to have a third of the hoard, with a safe armed escort back to Merchiston; but the affair of the Gowrie conspiracy against the king's life put an end to the speculation. Napier was alleged to hold secret correspondence with the devil, and to have a familiar spirit, in the shape of a *black cock*, which sat on the back of an arm-chair in his study; but this, and other stories concerning him, were the result of the ignorance of the age and his own Rosicrucian propensities.

When at college in his boyhood he contracted an intimate friendship with a Roman Catholic student, with whom he had many religious discussions in defence of the Reformers and their doctrines. At that time he was an attentive hearer of the sermons of "that worthy Englishman, Mr. Christopher Goodman," who had fled to Scotland after having given offence alike to Mary of England and her successor Elizabeth.

Goodman's interpretations of the Apocalypse and its mysteries, as applied to Catholicity, so impressed the mind of Napier, that, relinquishing his mathematics for a time, "he determined," to use his own words, "with the assistance of God's Spirit, to employ his skill and diligence to search out the remaining mysteries of that holy booke." So, soon after he published at Edinburgh, in 1593, his "Plain Discovery of the whole Revelation of St. John." This work he dedicated to James VI., and urged "His Majesty to attend to the enforcement of the laws, and the protection of religion, beginning the work of reformation *in his own house, family, and court*."

Amid his mathematical studies, it would appear that Napier paid some attention to the cultivation of poetry, for prefixed to his work is a metrical address to "Antichrist," and certain versified prophecies out of the Oracles of Sybilla. The same year found him appointed by the General Assembly of the Scottish Church, one of the commissioners appointed to assemble at Edinburgh, with reference to certain designs alleged to be formed at Rome for the overthrow of the reformed faith.

In 1596 he published a letter to Anthony Bacon (brother of the famous Lord Bacon), entitled "Secret Inventions Profitable and Necessary in these Days for the Defence of this Island, and withstanding Enemies to God's Truth and Religion," the original MS. of which is preserved in the library at Lambeth Palace.

This work had direct reference to Spain and the Armada, and re-introduced the ancient classic idea of burning-glasses, together with other strange devices, among which were a piece of artillery to shoot in *curved* lines, cross-bar or chain shot to cut away "the whole masts and tackling;" a round chariot of iron (the *iron turret* of the present day) made "double muskett proofe," ships for sailing *under the water*, "with divers other strategemes," he concludes, "for harming of the enemy, which, by the grace of God and worke of expert craftesman, I hope to perform." But the age was not one of progress, and his suggestions fell to the ground, like those of many inventors.

For several years he had turned his attention to the discovery of a quick and short method of calculation, to facilitate the solution of trigonometrical problems, and at length his efforts were crowned by the most complete success. In 1614 he produced his book of logarithms, styled by Sir John Leslie "the noblest conquest ever achieved by man." This work, entitled "Mirifici Logarithmorum Canonis Descriptio, etc., authore ac inventore, Johanne Nepero Barone Merchistonii, etc., Scoto," was printed by Andro Hart, of Edinburgh, and dedicated to Prince Charles, afterwards Charles I. The Scottish mathematician thus attained that which the schools of Greece and the lights of Germany had failed to accomplish.

Logarithms in calculation are what the steam-engine is in mechanics. They enable the calculator to overcome every obstacle, and render the most intricate combinations of numbers comparatively easy. Before the time of Napier, philosophers devoted days and weeks to computations, which now may be accomplished in a few hours. The world suppose mathematicians to be mere calculators; but few men calculate less, if the number of characters employed be considered. By the aid of logarithms they are enabled with a very few figures to compute quantities which would utterly baffle the ordinary mathematician. Their use shortens nearly every arithmetical calculation.

"Though logarithms," says Professor Playfair, "had not been invented by Napier, they would have been discovered (eventually) in the progress of algebraic analysis when the arithmetic of powers and exponents, both integral and fractional, came to be understood. The idea of considering small numbers as powers of one given number would then have readily occurred, and the doctrine of series would have greatly facilitated the calculations which it was necessary to undertake. Napier had none of these advantages, and they were all supplied by the resources of his own mind." And it is a proud reflection for Britain, as a great maritime nation, that she does not owe to a stranger the creation of that intellectual aid, which renders her fleets as free and as fearless in navigation as they have ever been in battle; but to an obscure Scottish gentleman, born and bred amid the civil wars of the sixteenth century.

This important discovery made the name of Napier known to the learned over all Europe; and Kepler dedicated his "Ephemerides" to the inventor of the logarithms, whom he deemed the greatest mathematician of the age.

In his last work, entitled "Rabdologia, seu Numeratio per Virgulas," in two books, published in 1617, the year in which King James revisited Scotland, he describes a method of performing operations of multiplication and division by a number of small rods, which continue to be known and used by the name of "Napier's bones."

Agriculture occupied some of his attention, and he had a plan announced for making land more profitable, by sowing it with salt; but as this was supposed to be the suggestion of the devil or the black cock before mentioned, the Scottish farmers were in no hurry to adopt it.

"When you have sown your white seed," he wrote, "you may sow for every boll of wheat, upon reasonable stiff or clay-land, one half boll of salt thereupon, and in sandy ground one firlot of salt; and let all be harrowed together, and hereby, God willing, you may have a good clean crop. In like manner when you have sown your oat-seed, you may sow three firlots of salt upon every boll of oats; but this must be done upon watery or laigh (*low*) land only, as upon meadow land, whereupon the water stands commonly in winter, ye shall, God willing, find a rich crop. But upon dry land ye shall sow no salt, where the oat-seed is presently sown, but before Martinmas, except with wheat, as said is, else ye shall rather lose than gain. Ye shall sow no salt with bear (barley) instantly neither upon wet nor dry ground, but as long before Martinmas as you may, as said is."

Napier was twice married; first in 1571, to Elizabeth, daughter of Sir James Stirling, of Keir, by whom he had a son, Archibald, afterwards first Lord Napier, a zealous Cavalier and adherent of King Charles; and secondly, Agnes, daughter of James Chisholm, of Cromlix, in Perthshire, by whom he had five sons and five daughters. One of the daughters, Margaret, became the wife of Sir James Stuart, of Rosythe, who is said to have been thus connected with the family of Oliver Cromwell.

On the 3rd of April, 1617, this illustrious mathematician died in his old patrimonial tower of Merchiston, which is now occupied as one of the principal schools in the Scottish metropolis, and was buried in St. Cuthbert's Church, outside the western gate of that city.

His eldest son, who succeeded him, was for his services and loyalty created Baronet of Nova Scotia by Charles I., and in 1627 was raised to the peerage of Scotland by the title of Lord Napier, which continues to be borne by his descendants.

A tomb belonging to another family, on the north side of St. Giles's Church, by popular error is always styled the resting-place of the great inventor, simply because it bears the name of Napier. Several portraits of him have been engraved from the original, which is preserved in the University of Edinburgh, and was painted in 1616, by whom unknown, but it was presented to the Senatus by his descendant, Margaret, Baroness of Napier, to whom his honours opened in 1686.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

VI.—CLASSIFICATION OF EXHIBITS (*continued*).

The system of fixing certain days for the delivery and removal of goods to and from particular classes, prevents the universal confusion that prevailed on former occasions, when exhibitors and their assistants belonging to all classes were allowed to bring in or remove their exhibits at one and the same time.

It is proposed to extend a series of International Exhibitions over a period of ten years, so that each class of the manufacturing sections may be brought under review decennially, according to a scheme laid down by Her Majesty's Commissioners for the Exhibition of 1851, which is now obtainable from their official at Kensington Gore. The divisions for scientific and new discoveries of all kinds, and fine arts, will, however, occur *annually*, so that the public may be kept informed of the latest efforts in science and art. The International Exhibitions of new and rare plants, and of fruits and vegetables, showing specialities of cultivation, will also be held annually by the Royal Horticultural Society in conjunction with the above Exhibitions.

Thus far I have endeavoured to give a digest of the general principles of construction,* arrangement, and management that recommend themselves for imitation at future exhibitions, and such comments on matters that demand correction, as my experience as a contributor to all our exhibitions from 1851 suggests. Among the multitude of details that demand attention for the satisfactory working of an undertaking of this nature, together with the conflicting interests that have to be considered and humoured, errors of judgment are sure to arise. Faults of arrangement and management can, as a rule, only be discovered after they have been carried into practice, but then both exhibitors and officials ought to endeavour to eliminate whatever has proved unsatisfactory, and profit by what experience has shown to be good, never forgetting to discuss the differences of opinion that may arise from their respective stand-points with mutual forbearance and courtesy.

In concluding the subject of International Exhibitions, it may not prove unprofitable to consider whether the buildings that have been erected at South Kensington as a permanent institution might not be modified so as to correct some of the shortcomings noticed in a previous article.

The present building consists of long galleries forming three sides of a square, connected by two curved covered ways with the conservatory of the Horticultural Society, and by that with the Albert Hall, the garden of the Society being enclosed by the entire range of these structures. Between the "Exhibition Galleries" and the gardens run a parallel range of open arcades, used in 1871 for the coarser kinds of pottery, gymnastic and boating appliances, refreshment bars, etc. The galleries are two storeys high, the upper floors in each being devoted to pictures, statuary, and other works of art, which at various points give access to the roof of the arcades, that serves as open-air promenades overlooking the gardens. The ground between the Albert Road and the west galleries is quite unoccupied, and that between the east galleries and the Exhibition Road only partly covered by the buildings devoted to the French Annexe and the Council Room and Floral Bazaar of the Horticultural Society, while the South Gallery is a long narrow structure forming a remnant of the Exhibition building of 1862.

Regarding it as possible that the Royal Horticultural Society could find accommodation for their council room and offices in the Albert Hall, the curved covered ways on the ground floor could most appropriately be devoted to a floral or horticultural bazaar. The ground between the west and east galleries and the public roads could then be occupied by additional dwarf (or one-storeyed) galleries and covered ways next the Albert and Exhibition Roads for the convenience of carriage visitors, as an especial provision for wet days—a shortcoming greatly felt in the arrangements for 1871. Thus, on the day before the close of the Exhibition the rain came down in torrents, especially at the hour when the visitors were being "rung out," and the wind drifted the rain through the large open carriage entrances of the Albert Hall in drenching showers of spray. Crowds of handsomely-dressed ladies, waiting for their carriages to come up, were forced by the police, *under the orders of the door-keeper*, from the shelter of the hall, and the supply of public conveyances being quite inadequate to meet the demand at this point for shelter at any price, the mass had no help but to "grin (rather savagely!) and bear it." Common sense indicates that provision should be made, when there are large assemblies of people, against health or dress being injured during wet weather. Such accommodation is provided at Sydenham Palace, and ought to be arranged for at next year's Exhibition. The dwarf galleries on the west side could be arranged for the permanent features of the annual series of Exhibitions—viz., machinery in motion and new mechanical and scientific inventions, while those on the east side could be employed for the requirements of other but varying classes, specified for each year's exhibits. These galleries run in unbroken parallel lines, a form of construction best suited for carrying out the proposed arrangement of the subdivision of *each class* into *nationalities*. The space that apparently is required for carrying out this reform would thus be provided and waste land utilised. While the outer walls next the public road, east and west, might be of brick, the internal supports might be arranged in the elegant iron-work adopted in 1851, and be roofed with glass on Paxton's ridge-and-furrow system, as may be seen at the Sydenham Palace.

The western and eastern arcades and galleries should likewise be made continuous for the class-divided-into-nationalities system, so that all the class galleries, whether on ground or upper floor, should merge into a grand hall, that could be erected across the lower end of the Horticultural Society's

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* For details of construction of Paxton's system, see Vol. I. of the "Illustrated Official Catalogue" of the Great Exhibition of 1851.

Gardens, in the position occupied by the Exhibition Building of 1862, where the galleries behind the dining-rooms now stand: that would repeat the best features of 1851 and 1862, the want of which, as previously stated, made itself felt in 1871. To the height of two storeys the walls of this hall might be of brick; above that, and a third of the entire height, the structure should be continued in ornamental iron framework glazed, and in part relieved by coloured glass, the whole length being covered in with a glazed arched roof, after the style of Paxton's transept of 1851, now transferred to Sydenham. Each end of this building should comprise grand entrances on the ground floor, organ lofts on the upper floor, and the glazed part should be of rich design in stained glass, embracing the dial-plate of a monster electric clock. Galleries should run round this hall, which on the north should give access to the picture galleries. In the centre should be arranged the basin of a fountain, that on the occasion of state ceremonials could be covered in to form a dais. The grand hall should be devoted to the display of statuary in connection with artistically arranged groups of tropical and other plants, banners and armorial shields of nations, provinces, and trades; on the walls and from the roof of the galleries should be displayed pendent specimens of tapestries, carpets, wall decorations, papering, etc.; and in gallery cases, shawls, lace, engraved ivory, metal-work and precious stones, designs of porcelain, and other objects shown as art productions. The centre of this hall should be artistically arranged with the more imposing groups of statuary, organs or other large musical instruments, trophies of science, art, and manufactures, connected with the special series of objects belonging to the year's programme. Such a hall would form an imposing and attractive feature to the mass of the public, and during the off season it might be utilised as a winter garden.

If, after due consideration, *it is* deemed advisable, with the object of securing abundant contributions from the Continent, for the sake of "profit," if not "glory," to introduce the bazaar element at future exhibitions, then let the stalls be established apart from the main body of the galleries, in the east and west theatres and vestibules of the Royal Albert Hall, and charge a rental to those English or foreign exhibitors who wish to have shops whereat they can make direct sales of goods "across the counter." The offices for exhibitors, catalogue distributors,* and agents might here find suitable quarters, and in a position readily discoverable by casual visitors.

If it be the intention of the managers of these annual exhibitions to place before the world a series of exhaustive illustrations of the different methods followed in various countries in the conduct of the manufactures selected for each year (but with greater evidence of pre-organisation than was evidenced in the educational collections for 1871), it will lead to an interchange of ideas that ought to prove to the mutual advantage of manufacturers and the progress of civilisation.

PAPER AND CARDBOARD MAKING.—VI.

BY GEORGE TINDALL.

MILLBOARDS, CARDBOARDS, ETC.

ALTHOUGH the use of the watermark as a trade mark is now almost entirely abandoned, its value as a means of preventing forgery and as a safeguard for bank-notes, bills, cheques, etc., is very great, and its use has latterly been much developed by the invention of a means by which gradations of light and shade can be given to the paper, instead of the system of simple lines formed by wires, formerly used. Exemplifications of this process may be seen in the Bank of England notes and in postage and receipt stamps, every one of which has an elaborate watermark in addition to the very intricate designs printed on the surface, so that in order to counterfeit any of these, it would be necessary to have paper specially made for the purpose, in addition to the trouble of engraving and printing. These effects are produced from an engraving on copper or steel, similar to one prepared for printing, either by taking an electrotype which is affixed to the surface of the wire gauze forming the mould, or by using the engraving as a die, and by great pressure with a steam-hammer or otherwise, taking an impression from a thin sheet of brass, such portions as enter the lines engraved on the design being transferred to the mould, or the die is used to give the impression direct to the fine wire gauze of the mould; but in the latter case the mould must be most carefully used, as the design is soon defaced. In this way the most intricate designs may be permanently introduced into the texture of the paper, as well as the delicate effects of light and shade forming a landscape or a portrait, and at the cost of a few pounds for moulds or a dandy-roll, the exclusive use of a paper may be secured to an individual or a corporation, with an autograph, crest, or other design suitable for their use.

Waterlined brief papers are still largely made by hand, and used for legal purposes. The lines are formed by the introduction into the mould of plain wires across a wove surface, and consist of a margin line and thirty-six or forty parallel lines commencing at the margin line. A great variety of machine-made papers with the surface either lined by watermarks, or covered with designs formed in the same way, by means of special dandy-rolls, are now imported into this country from the Continent and largely used for correspondence and other purposes, whilst a small quantity is also made in England; but the use of these papers is still very limited, whilst the use of specially watermarked papers for commercial purposes is very largely increasing.

Watermarks have at various times been valuable adjuncts in the detection of crimes in courts of law; while, on the contrary, the careful study and use of watermarks enabled the celebrated forger, Ireland, for years to fabricate and pass off as genuine emanations from the pen of Shakespeare, a very large quantity of manuscripts which, at the time, deceived many of the ablest critics of the day. In a pamphlet which he afterwards published, Ireland says that he purchased the fly-leaves of old books, and being at first wholly ignorant of the watermarks used in the reign of Elizabeth, he was careful to produce his manuscripts on such sheets as were entirely without watermark; but as the demand for his wares increased he feared that this might be noticed, and learning that a jug was a common watermark of the period at which his manuscripts were supposed to be written, he made careful search for sheets of paper with this device, and afterwards introduced a certain number of sheets with this watermark in his spurious documents. This was doubtless the mark formerly used for pott papers described in our last article (Fig. 3, page 161).

Having now fully described the process of paper-making, we proceed to the manufacture of boards, of which there are two very different and distinct kinds—millboards and paste or card boards. Milled or millboards were, up to a very recent period, used exclusively for bookbinding purposes, but the inquiring and inventive spirit of the past twenty years has found almost innumerable uses for this very useful article, the chief one being box-making for drapers, milliners, and a host of other trades; they are also largely used for machine packing, and even for the inner soles of shoes. This increased use, of course, requires an increased supply, and whereas formerly millboards were made of old tarred rope and such materials as were used for strong brown papers, now hundreds of tons made almost entirely of straw are imported into England from the Continent, whilst large quantities are made here from very inferior materials, such as flax and jute waste. Hopbine has also been successfully tried for this purpose. In the making of these boards, the process, as far as the formation of the waterleaf, is precisely the same as that described in making paper by hand; but instead of placing a felt between each sheet of paper, as many sheets of waterleaf as are required for the thickness of the board to be made are placed one upon the other, and then a felt is placed upon the whole. Then another board is begun, and the same process is continued. When these are pressed the sheets become one homogeneous board, and they are afterwards treated like hand-made papers, being again pressed without felts, and then hung up in lofts to dry. Some of these boards have a beautifully-polished surface given to them by friction glazing; this is performed by a smooth piece of agate fixed in a framework, and having a regular motion given by suitable machinery; by this means a surface of about two inches is glazed by burnishing at once, and successive portions of the board are brought under the action of the tool until the board is completed and has a surface like a plate of glass. A considerable number of very thin boards, and especially straw boards, are now made at machine like ordinary thick papers, while some boards for engine packing are made nearly an inch in thickness.

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* No provision was made in 1871 for obtaining exhibitors' catalogues, though often they were tantalisingly displayed behind the glass of their cases; the attendants could afford no assistance in procuring copies. This shortcoming was especially vexatious in connection with valuable foreign exhibits, as the exhibitors' *addresses* were not given in the Official Catalogue of the Industrial Department till, quite late in the season, the "Index" was published, consequently communication with exhibitors was to a great extent barred.

Pasteboards and cardboards although sometimes made as thick as ordinary millboards, are produced in a very different manner. In this case the various sheets of which the board is composed are made at machine in the ordinary way, and consist of a middle which for pasteboards is of inferior quality, and two outside sheets which are pasted on to the two sides of the middle, and being pressed a firm thick sheet is the result, the surface being, of course, of the finer quality of paper used for that purpose. If a very thick board is desired, two or more middles may be pasted together and then covered, whilst middles and outsides of various thicknesses may be used, and thus any weight of board may be obtained. For white pasteboards a very white or light grey middle is used, made of materials somewhat inferior to those used for fine printings, the principal requisites for a good middle being evenness of texture (as lumps show up after pasting through the covering) and colour, if for white boards; bulk is also an important consideration, as, of course, the thickness of the board depends most on the middle, and any attempt to load a middle by the addition of mineral matters to some extent defeats itself, as a heavier middle is required to secure the thickness of the board. For coloured boards such as are used for railway tickets, bonnet-boards, etc., a very common brown or grey middle is used, its quality being hidden by the coloured surface-paper. Cardboards are made in the same way, but being a better description of board the middle is usually of as good a quality of paper as the coverings, and after making they are pressed between heated zinc plates in the same way as fine papers are treated for plate glazing; this gives them a fine polished surface, as well as making the board firmer and harder. A fine, thin cardboard called ivory is made from two or more sheets of fine paper pasted together and rolled until a beautiful hard, smooth surface is produced. This is used for visiting and address cards, and for fine printing. Many cardboards are also surface-stained or enamelled by coating the card with a white or coloured composition and rolling until a good surface is obtained, as in the case of enamelling; a beautiful, smooth, and shining surface is the result of continued rolling. These operations are not usually conducted at the paper mill, the business of cardboard and pasteboard making being separate from that of paper-making, and oftener carried on in towns, while paper-mills are usually situated at some distance from large towns—except mills where coarse papers are made—on account of clear water being a very great desideratum in the production of fine papers.

Besides the important branches of millboard and cardboard making, some other applications of the paper manufacture are worthy of our attention, and of these we will notice the manufacture of articles of clothing and furniture. For many years past the use of collars, fronts, and other articles of wearing apparel made either entirely of paper or of paper in connection with linen fabric, has been steadily increasing, until this has become an important branch of the manufacturing industry of this and other countries, particularly of America, and a great number of persons are employed in this branch of commerce. In China, Japan, and some other countries, the use of paper for handkerchiefs, coverings for the head, and other articles of dress, has been known for many years; indeed, scarcely any substance is capable of being applied to so many purposes or of being made up into such a variety of useful and ornamental articles as paper. It can easily be made waterproof, and so form a shelter from rain as well as the heat of the sun; when in the shape of pulp it can be moulded to any required form, and it dries hard and firm so that it can be used for furniture, and even for building houses, and in this state it is almost fire-proof. Excellent window blinds printed in a great variety of patterns are now made from it; indeed, the uses to which it is applied are almost numberless, for it has been proposed to use it as an armour for ships in lieu of steel plates, under the belief that it would be a greater safeguard than steel and iron, whilst it would certainly be very much lighter, and so would not affect the sea-going qualities of vessels to which it was applied. After this we can easily believe that houses may be roofed or even built with it; that, in fact, there is no limit to the purposes for which it may be used. In the manufacture of furniture and wearing apparel, however, the processes are widely different; for the former, the pulp must be manipulated, whilst for the latter, the perfect sheet of paper made in the usual way is taken and treated by the makers of these articles.

Simple paper collars, etc., are made from a sheet of stout paper which is first passed between rollers to give it a surface, or is glazed in the usual way between metal plates. It is then placed in a press, and at one simple operation the collar is cut out clean by the descent of a punch or die, which at the same time impresses any pattern that may be required, and the collars are then folded and packed in dozens in neat round boxes which are likewise made of paper and pasteboard or millboard. Collars made of paper only are now, however, almost entirely superseded by linen-faced fabrics; in this case the sheet of stout paper is covered on one side with a roll of thin fine linen in the same way as the middle of a pasteboard is covered with the fine outside sheet, and by pressing and rolling the linen is incorporated with the paper and a fine glazed surface is obtained. The collars are cut out in the way just described, the products being stronger and finer, and very closely resembling fine linen. Fronts, wristbands, etc., are made in the same way, a great number and variety of dies being required for the various sizes and patterns now in use; and in some cases, where an elaborate pattern is stamped upon the article, this is done after the required shape has been cut by a punch by placing it between two plates, on one of which the required pattern has been engraved, and the other cast or moulded from it; these plates are then passed between a pair of rollers under considerable pressure, and by this means the paper is forced into the sunk spaces of the engraved plate, and stands out in bold relief when taken from it. The cuttings from the sheets, which are necessarily somewhat large, are returned to the paper-maker for re-manufacture; in many cases they are worth half their cost for this purpose, and are eagerly sought after, as are also the cuttings made in the manufacture of envelopes, and the shavings from book edges and other cut papers; when these shavings are clean they may be readily converted into pulp, and lose but little in the process.

The use of paper in covering the walls of rooms, etc., has now almost entirely superseded the old method of whitewashing or painting, and has been extended to the humblest dwellings in the land; for this purpose, also, the paper is made in the usual way, but in a continuous sheet about twenty-two inches wide, known as "long elephant." The staining or printing of the pattern is rapidly accomplished by very beautiful and simple machinery, the several colours being laid on at one operation, except in the case of very fine paper-hangings, for which the old process of block-printing by hand is still used; the papers are then cut in lengths of twelve yards, and rolled up in pieces for sale; and so rapid and cheap is the operation that a piece of paper-hanging twelve yards long, with a design beautifully printed in several colours, may be bought for a few pence.

For window blinds a broad and very strong sheet of continuous paper is used, and this is first passed through a bath of very strong size before the design is printed; afterwards it may be varnished, and in this state the surface may be washed if care is used, otherwise it can only be worn until it is dirty.

For ordinary furniture a very different method of manufacture is followed: the pulp is prepared as for paper, and consists for the most part of waste papers broken up in the engine, and run into drainers, as described in the early portion of these papers. This half stuff, as it may be called, is then taken and moulded into the required form, and after drying is varnished and polished. Articles made in this way are termed *papier maché*, and very light and durable tables, chairs, trays, and numberless other articles of furniture are produced at very small cost, the principal objection being that this substance has not the same power of retaining a firm hold of nails, screws, etc., which is possessed by wood, so that for articles requiring hinges or other similar arrangements it is not so suitable, but it may be turned in a lathe or moulded to any shape in the condition of pulp, so that it is very suitable for articles made in one piece only; it is also susceptible of a considerable amount of ornamentation by inlaying with mother-of-pearl and other substances, which is easily done when the article is in the damp soft state.

We have thus indicated some of the various *extensions*, so to speak, of the paper manufacture, though nearly all of them form separate and distinct branches of commerce, and some of them will, no doubt, receive separate, and full treatment in the pages of THE TECHNICAL EDUCATOR. Perhaps no kind of manufacture has had so large an extension in various directions as this, and perhaps no other has so largely taxed the ingenuity of its followers to supply it with the materials for its extension. Made originally from the refuse and waste of other industries, the whole surface of the globe is now ransacked for fresh fibres suitable for direct use in the manufacture of paper. Large sums have been offered as a reward for the discovery of such fibres, and the attention of many intelligent men in our colonies and elsewhere is now attracted to this subject, so that we may fairly hope that as the use of paper increases we shall be at no loss to supply the demand. The importance of this industry to every branch of art and science and to everything that tends to the elevation of mankind is incalculable, and anything calculated to facilitate or to improve it is a matter of more than national importance.

CIVIL ENGINEERING.—XVI.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

HARBOURS.

OUR attention in previous chapters has been directed to those *exterior* appliances by which engineers have been enabled to protect certain parts of the coast against the violence of the sea, and to afford shelter to vessels when within their influence. We have now to speak of the harbours themselves.

And first in importance amongst the various matters which arise in connection with this subject, is the *depth* of water obtainable at the lowest point of the tide; because a mere *tidal* harbour—that is, a harbour only accessible to vessels at certain periods before and after low tide—is, after all, of only a limited value. There are not many positions on our coasts, whether sheltered by nature or art, which possess naturally a depth of water sufficient to float large vessels at all times of the tide. Indeed, some are mere mud-banks when the tide is out, exhaling poisonous effluvia. Now much of this evil is remediable.

Before, however, we point out what are the means usually adopted for obtaining and maintaining a proper depth of water in a harbour, let us see whence the causes of the evil arise. Briefly, they arise from two sources, the effects of the sea and the effects of the land-water. The same action and force which forms sand-banks, produces bars at the mouths of rivers, and throws up pebble ridges, as at Weymouth and Westward Ho, will throw mud, sand, beach, and boulders into a harbour, and if not prevented, sooner or later render it useless. When in 1774 Smeaton was requested to report upon the state of Ramsgate Harbour, and the cause of, and the remedy for, its choked condition, he found it to contain 268,700 cubic yards of silt, which was still being deposited at the rate of one inch every five weeks. The whole of this mass had been brought into the harbour by successive tides. The water upon this part of the coast is highly charged with a mixture of mud and very fine sand whenever agitated by the wind, and this silty water, finding repose in the harbour, deposits the heavy matter held in suspension, the water alone being taken back by the receding tide. This, which occurs at Ramsgate, will occur more or less at every harbour in which the enclosed water finds almost absolute repose; and the smaller the harbour, the greater its tendency to become silted up, because the back-flow of water at ebb tide is insufficient to carry back the deposited matter. This fruitful source of mischief to a harbour was almost unknown to the ancients, because the Phœnicians, the Greeks, the Romans, indeed all the old maritime nations, inhabited countries whose ports and harbours were situated on an almost tideless sea; hence we are left without record as to the plans which may have been adopted by them for remedying the evil if it existed.

Another fruitful source of mischief to a harbour is the earthy matter brought down by freshets from the interior, in the case of a river finding its way to the sea through a harbour. This earthy matter which, held in suspension, might have been carried completely out to sea if it had had an unopposed course, will generally meet with a check at the flow of the tide, and the water being thus brought to a stand-still, the same result will follow as that already indicated, the suspended matter becoming deposited in the harbour. An instance of this kind occurred at Aberdeen previous to the improvement of the harbour by Smeaton. The river Dee, which admitted the tide to flow upwards about two miles, and to spread itself over some very flat ground, did not acquire sufficient strength to carry out all the deposits that were borne down from the land in the interior through which the river flows. The tide, meeting the fresh water, occasioned the sand, stones, and mud to be deposited, and at last a bar was formed, which almost obstructed the entrance for large vessels. Smeaton discovered the cause of the deposit, and finding the river spread over a space upwards of 500 yards in breadth, he decided upon confining it within a narrower channel, and it was for this purpose that he constructed the North Pier.

This course, which proved successful in the case of Aberdeen, could not, however, be adopted in all instances; and indeed in that particular locality the old harbour, which was nothing more than the improved mouth of the river Dee, was found insufficient for the necessary accommodation, and was subsequently abandoned for artificial wet docks. Every separate locality will inevitably require its own special treatment, and hence no absolute rule can be laid down for the best method of removing deposit from a harbour, and of keeping it free. We may, however, be guided by general principles, and a careful study of the works of Smeaton, Telford, Rennie, and some of the French engineers will be the best guide to the arrangements which have proved successful in the majority of instances. It will generally be found the most efficient, and at the same time the most economical plan, to allow Nature herself to provide the remedy, assisted by a skilful application of art. If *water* has been the means of introducing the deposit, let *water* remove it. If the mud came from the land, brought down by the even flow of the river or stream, endeavour to arrest the even character of the flow, and make it intermittent, employing the pent-up water at certain periods, so that its increased flow at these times may scour the harbour, and carry the deposit far out to sea.

Probably no country has been so successful in the improvement of their harbours by the adoption of sluices for scouring them as the French. We might conduct our readers round the greater part of the sea-board of France, and show them the numerous costly, ingenious, and successful contrivances adopted by their engineers for washing away the silt from the bottom of their harbours. A few instances will, however, serve to illustrate their arrangements.

Dunkerque, or Dunkirk, presented one of the earliest and perhaps one of the finest specimens of marine engineering in France. So far back as 1689 contrivances for deepening the port and keeping it clean were adopted by M. Clément, one of the most celebrated civil engineers of his day. The harbour was provided with no less than five independent sluices, which could be used either singly or collectively. The principal sluice was at the end of the canal of Bergues. It was 26 feet in width, fitted with a double pair of gates. One of these gates supported the waters of the canal, the other those of the sea at high water. The land-water was retained by the upper gates until the period of low tide, and the scouring effect of the waters which were then discharged was felt to the end of the jetties, a distance of 3,500 yards. By means of this sluice, combined with a second 15 feet wide at the mouth of the canal of Moère, and a third at the canal of Furnes, the port was cleaned and scoured out to the depth of 15 feet.

There was, however, a sluice larger than either of the above constructed by Vauban in 1684. This was 42 feet wide, and the gates supported a weight of water 20 feet high. The foundations of the sluice were laid on a moving sand, into which were driven eight rows of piles. These were connected by as many pairs of binding pieces, between which were driven a double row of sheet piles, the joints of one row covering the joints of the other. Between the heads of the piles a foundation of brick was laid, which was brought up level with the tops of the binding pieces. Between the several rows of sheet piling were laid cross timbers, which extended throughout the whole width of the foundations which were to be occupied by the sluice. The spaces between the timbers were filled in with masonry, and the whole brought to a level. A floor of oak plank was then laid over, pinned, and securely caulked at the joints. Other cross timbers were laid on this floor, and altogether an unnecessary quantity of wood seems to have been employed. The water for sluicing was allowed to flow out through aqueducts left in the masonry of the side-walls. These were 3 feet wide internally, and arched with stone, being lined throughout with hard stone to resist the friction of the water when rushing out. The aqueducts were closed by paddles 3 feet 6 inches wide, working in iron grooves introduced into the masonry. The paddles, which had to sustain a considerable pressure of water, were raised and lowered by means of a nut turned by levers which threaded upon a screw cut in the iron rod attached to them.

The port of Cherbourg is another instance of a harbour whose depth is maintained to 18 feet by successful sluicing. The river Yvettes is let into the inner harbour by the opening of the gates of a large sluice, and the accumulated mud is ploughed up and carried out to sea.

It is by no means necessary that a natural supply of water for sluicing purposes should exist. When such is the case, it becomes of course the more economical; but frequently there exists not even a small stream whose water can be rendered available by accumulation. At Boulogne the small stream, the Lianne, which would be entirely inadequate in its natural condition to keep the harbour clean, is allowed to flow into a large basin whose level is considerably above the water of the harbour at low tide, and there it accumulates during the period from one tide to another, and thus acquires a volume and force of discharge amply sufficient for scouring purposes.

In other cases, as at Tréport and at Ramsgate, the water for scouring is obtained directly and exclusively from the sea. An artificial basin is formed, communicating by gates with the harbour. The rising tide opens these gates and fills the basin to its own level; the gates close as the tide recedes by the superior weight of water upon the inside, and are retained there until the tide has fallen sufficiently low, when the sluice-gates are opened and the scour follows. This is one of the most efficient methods for keeping a tidal harbour free of the deposits which tend to form therein.

Another method, less efficient and more expensive, because the cost is continuous, is by dredging. This system is adopted in very many localities, and amongst them at Hull. The waters of the Humber flow over vast mud-banks, and contain earthy matter in suspension in immense quantities. This is deposited to a very great extent in the docks, it being calculated to amount annually to 36,000 tons in the Humber Dock alone, which contains an area of a little more than 7 acres, being 914 feet long, and 342 feet broad. The dredge may be generally described as an iron bucket with a sharp-edged, broad, projecting lip, the bucket being perforated at the bottom and for some extent up the sides to allow the water to flow out. The bucket is lowered to the bottom, and drawn along the soil sideways, and is then brought to the surface filled with mud; the water which comes up with it flows away through the perforations. The mud which remains behind is then discharged into a lighter. The steam-dredging machine is an arrangement for carrying out the principle upon an enlarged and improved scale. It consists of a series of buckets similar to those already described, fixed at intervals upon the outer side of an endless chain consisting of long iron links, the chain passing over a square tumbler worked by steam-power. The buckets descend into the water upon one side of the chain, and touch the bottom mouth foremost, scooping up a quantity of mud, and rising upon the other side of the chain full of soil, which falls out of the buckets as they pass over the tumbler, and is caught by a lighter moored below. The machine employed in the Humber Dock is placed on a flat-bottomed vessel which draws 5 feet of water. It is worked by a steam-engine of 6-horse power. By means of a bell-crank motion is given to cog-wheels. On the axis of the upper one is the square tumbler, with a corresponding one at the lower end of the bucket-frame. There are twenty-nine iron buckets on the chain, and the exact depth to which they descend is regulated by a crab and tackling, from which the lower tumbler-wheel depends. About from forty-five to sixty tons of mud can be raised per hour; this is deposited in flat-bottomed mud-boats drawing 6 feet of water, and capable of carrying forty tons of mud. Care must be taken to convey away the mud which has been dredged to a sufficient distance out to sea, in order that the action of the tide shall not bring it back to the harbour.

In order that a harbour may be of use to the shipping frequenting it, it requires not only to be sheltered from the violence of the sea, and to possess a sufficient depth of water for vessels to ride securely, but it must have good anchorage. The natural character of the ground may form a sufficiently good hold for ships' anchors, in which case it may not be necessary to lay down moorings for ordinary purposes. But to facilitate the departure or movement of vessels, buoyed moorings are extremely valuable. Such a mooring consists usually of a screw forced into the ground, having a moving or swivel head, as shown in Fig. 37.

The harder the ground into which the screw has to be forced, the heavier and stronger the screw is required to be. A screw weighing 9 cwt. will form an efficient mooring. For a mooring-chain 1¼ inch diameter, the diameter of the disc or screw should be 4 feet, and the weight about 11 cwt. The character of a screw for mooring purposes varies according to the opinion of the engineer; some prefer a broad disc with few turns, whilst others consider a greater number of turns and a narrower disc preferable. The value of screws for holding purposes is very great. In 1851 an experiment was tried on the Godwin Sands with a hollow pile six inches diameter, fitted with a screw at the lower extremity. This was screwed down with ease to a depth of more than fifty feet, passing through a fine, compact sand. They have been employed in a variety of ways with great success, some of which we shall have occasion to refer to again more minutely.

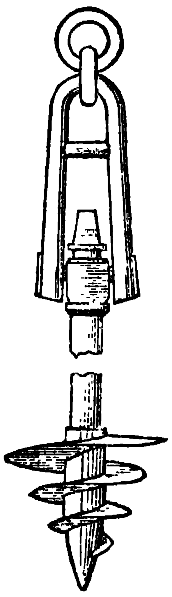


Fig. 37.

The head of the pile used for mooring purposes is fitted, as we have said, with a swivel. To this is attached one end of a chain, the other end being fastened to an iron ring fixed to a buoy, and having sufficient length to reach the surface of the water at the highest point of the tide, with a small amount of slack to spare. The buoy must have sufficient power of flotation to support easily the weight of the chain. Attached to the upper side of the buoy is a large ring, and to this the cables of vessels requiring to be moored are fastened. By this arrangement the vessel is very readily released, although whilst so attached it is more securely fastened than if it were riding at its own anchor. In rivers greatly frequented by shipping, as the Thames, it becomes necessary to lay down the buoys for the use of vessels in such positions as that the channel shall be kept free for passing ships. In order to render such buoys of use, it is necessary to compel vessels to employ them.

There are other accessories which are necessary to render a harbour useful to shipping. There should exist stores of all such materials as may be required for refitting disabled vessels—as, for instance, of sails, cordage, spars, anchors, and so on; also provisions and fresh water, and the means for readily gaining access to these stores. With respect to jetties, piers, wharves, etc., we have already directed attention to them.

The subjects treated of in these papers do not include military engineering matters, and it is therefore not our intention to enlarge upon the desirability of protecting the approaches to a harbour from the possible attacks of an enemy. It is natural to infer that in time of war the cruisers of an enemy will direct their attention to those points of coast in which their opponents' vessels would be collected, and hence such points require special defences. A very few guns of large calibre advantageously posted will prove of immense benefit in protecting the vessels which have sought refuge within the harbour; but a more efficient plan is to alter the bearings by which safe access is gained to the harbour, and thus to throw the enemy's ships upon rocks. This system, however, has its disadvantages, inasmuch as friendly ships may meet with the disaster intended for the enemy. Probably the most efficient plan for the military protection of a harbour is by the modern appliance of torpedoes. These most destructive implements of war, against whose power the strongest iron-clad is as helpless as the smallest boat, can be employed at will against any particular vessel it is desired to operate upon, by means of electricity, the wires conveying the current being laid under water to the shore, where they are placed under the charge of an operator, who by the simple pressure of a key completes the circuit by which the torpedo is instantaneously exploded.

Our next chapter will take up the subject of lighthouses, those most indispensable adjuncts to the entrances to harbours, and all exposed points of a coast.

MINING AND QUARRYING.—XX.

BY GEORGE GLADSTONE, F.C.S.

COPPER (*continued*).

SMELTING—LOCALITY OF WORKS—SWANSEA PROCESS—MODIFICATIONS—PRECIPITATED COPPER—FOREIGN PLANS—CHILIAN REGULUS.

SWANSEA and its immediate neighbourhood, Llanelly, Neath, and Pembrey, is the great centre of the copper-smelters. There are also some works at St. Helen's in Lancashire; and copper forms a subsidiary product of those vitriol works at Newcastle and elsewhere, in which pyrites are used as the source of sulphur. Reference to these will be found in "Chemistry applied to the Arts," Article XI.

Not only are one-half of the markets of the world supplied with their copper from Swansea, but the ores are sent there from every quarter of the globe to be smelted. Except, therefore, when mention is made to the contrary, the practices about to be described may be understood to be those adopted in South Wales.

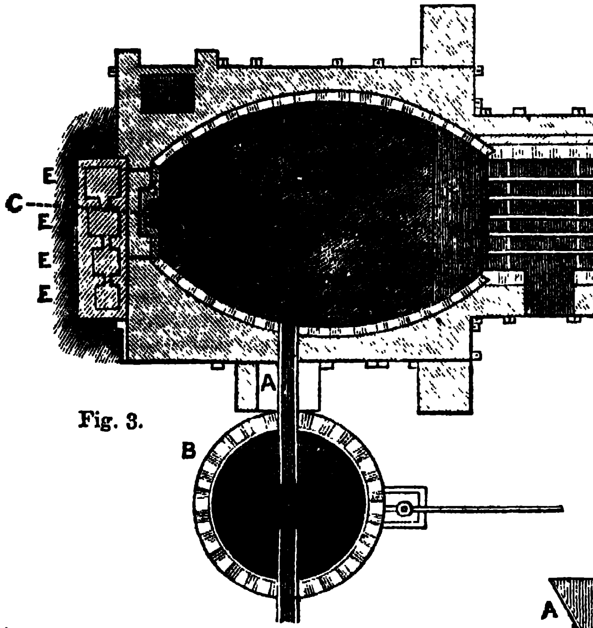
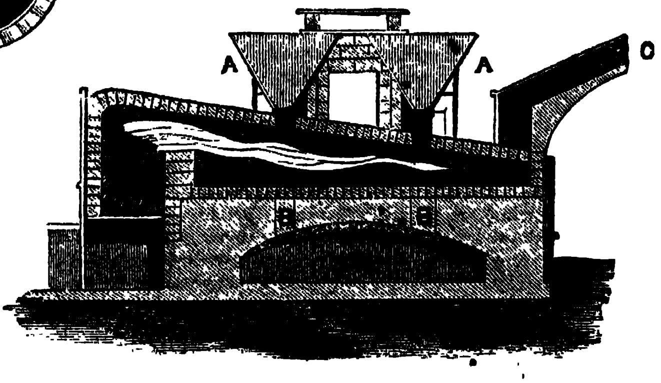


Fig. 3.

Fig. 2.



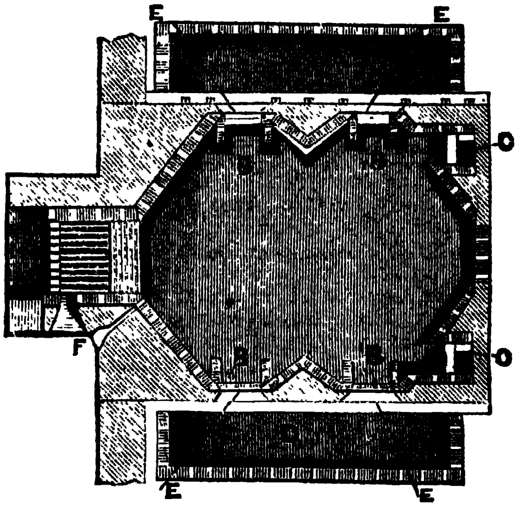


Fig. 1.

The ores have to be subjected to at least six operations in order to convert them into good copper; but sometimes as many as ten are necessary, when ores of a peculiar character, or very low per-centage, are smelted by themselves. In the large works it is customary to buy a number of different parcels of ore; low sulphides, some containing a large proportion of iron, and others much quartz or earthy matter, oxides and carbonates, and regulus, which is roasted ore, often containing 50 per cent. of metal. By a judicious admixture of these different descriptions, the number of operations, and therefore the cost of the reduction, is reduced to a minimum. How this is accomplished will be seen presently.

The first step is to calcine the ores for the purpose of driving off a portion of the sulphur with which they are combined. As the great bulk of ores consist of sulphides, this preliminary operation is always necessary; especially as the richer ores, such as the carbonates, are mostly reserved for use at a later stage. The calcination is performed in a reverberatory furnace, the ordinary form of which is shown in the accompanying diagrams, Figs. 1 and 2 representing the ground-plan and section. The charge is allowed to fall from the hoppers, A, A, upon the sole of the furnace, where it is subjected to a considerable temperature, but not sufficient to make the ore clot together; it is kept stirred at intervals by the furnace-men, who are provided with rabbles which are inserted through the working doors, E, E, so that all of it may be brought equally under the influence of the fire. The flues, C, are at the opposite end of the furnace. When the calcination is complete, the coverings to the openings, B, B, leading to the vaulted chamber, D, below, which are immediately inside the working doors, are removed, and the ore is raked through. The fuel used is coal, and the draught is so regulated through the furnace-bars, and by the air-passage, that the flame shall extend over the whole inside area. It is almost superfluous to say that in this and all subsequent operations the fuel should be as free from sulphur as possible, the principal object of the calcination being to drive off that element. From nine to twelve hours are necessary in this case, the time being somewhat dependent upon the character of the ore. During this process about one-half of the sulphur will have been expelled, and the copper thus set free will have been converted into an oxide; while the greater part of the arsenic which the crude ores may have contained will have been volatilised.

The principal object of the second operation is to separate the earthy matter and the iron, and to effect this the calcined ore is again heated in a reverberatory furnace of a somewhat different form, and at a higher temperature than before. The usual shape is shown in Fig. 3. The sole inclines downwards towards the pipe A, which leads to the tank B. The working door is at C, and D is the chimney. The charge, which consists of some fusible cupreous slag from some subsequent operations, in addition to the calcined ore, is passed in through a hopper, as in the former case, and is there left for three or four hours, the pipe A and the working door being both kept closed all the time. The charge soon melts, and the iron enters into combination with the flux, forming a silicate of that metal; during this transformation, the sulphur liberated from the iron is converted into sulphurous acid, which, in its efforts to escape, keeps the molten mass sufficiently agitated. Sometimes fluor-spar is added to the flux, which facilitates the fusion, and aids also in discharging any arsenic which may remain from the first calcination. The heat is then got up still higher, and presently the tap-hole is opened, and the fused matt which has collected in the lower part of the hearth opposite A, is drawn off through the pipe into the cistern. The viscid slag which overlies it is then drawn out with a rake through the working door, C, and is allowed to collect in the four receptacles, E, E, E, E; the two central ones are first filled, and the other two only take the overflow; the consequence of this is, that almost all the metal which has remained mixed with the slag (being of greater specific gravity than the rest) sinks to the bottom of the two central compartments, while the others contain so little as to be rarely worth recovering. When the contents are cold, the scoriæ are broken to pieces, and those portions which are worth melting again are added to the next charge. The tank B contains cold water, and the hot matt or regulus on falling into it becomes granulated so as to be ready for the next operation. It is now termed "coarse metal." It consists of a mixture of copper and iron, both in the state of sulphide, with little or no earthy matter, the latter having been entirely removed along with the oxygen and a part of the iron in making the silicate. A fair average sample will contain about 33 per cent. of copper, a similar proportion of iron, and about 30 per cent. of sulphur.

The next two steps of the process bear a great resemblance to those already described. The coarse metal is calcined in a furnace similar to the first, for the purpose of expelling more of the sulphur and reproducing the oxide; the 30 per cent. of sulphur being then reduced to about 17 per cent., and the loss replaced by so much oxygen. This product is then fused again to separate the iron, and leave as pure a sulphide as possible. The result of this is "blue metal," as it is called, consisting usually of about 57 per cent. of copper, 16 of iron, and 23 of sulphur. If, from any cause, such as the poverty or special character of the ores dealt with, or any faults in the manufacture, such a metal should not be attained at this stage, the processes already described are repeated until a satisfactory result shall have been arrived at; this will involve an addition of either two or four operations. On the other hand, if a large proportion of the red oxide or carbonate of copper is added to the calcined coarse metal before being melted again, a superior product will be obtained, called for distinction "white metal," which will contain scarcely any iron, and will almost equal a pure disulphide of copper.

We then come to what shall be termed the fifth stage—though in practice it may be the seventh or ninth—the making of "blister copper." The object of this operation is the expulsion of all the iron and sulphur remaining in the blue metal. The furnace is only raised to a moderate heat at first, and the air-passages are left open so that there may be a sufficient supply of oxygen to effect the decomposition of the sulphides and the formation of sulphurous acid. So long as this is being formed, the whole of the contents of the furnace are kept in a sufficient state of agitation to render rabbling unnecessary; but as soon as this part of the reaction is complete, the doors must be closed, and the furnace brought up to a higher temperature and kept at its full heat for about twenty-four hours. The remaining part of the sulphur is thus expelled, and the oxides which have been formed during the previous part of the roasting are converted into silicates, which separate from the metal as a slag. The latter is then skimmed off, and the copper is allowed to run through the tap-hole into moulds. The blister copper thus obtained should contain from 93 to 96 per cent. of pure metal, the principal other ingredient being oxygen. The slag which has been separated from it will be found to contain a good deal of oxide of copper, which is recovered in some of the earlier operations.

Only one more process is now required to convert the blister copper into an article fit for the market. This is the refining. A large reverberatory furnace of the ordinary form is employed, well arranged for maintaining a high temperature, which is charged with six to ten tons of blister copper at a time. The heat to which it is raised causes the metal to melt in about six hours, and the temperature is still increased so that the oxygen may become combined with the silica, and form scoriæ, which will float upon the surface. After an exposure to this intense heat for about twenty hours, the furnace-man rakes off the small quantity of scoriæ that is overlying the metal, and then draws a sample of the copper in a ladle, which is tested as soon as cold. From the appearance of the fracture the refiner judges how to treat the contents of the furnace. Some charcoal or anthracite dust is thrown upon the surface of the molten metal to prevent it from absorbing any oxygen from the air which passes through the furnace, and the remainder of that gas which may still remain in combination is dispelled by poling, a billet of greenwood being employed for the same purpose as has already been described in treating of the refining of tin. During the poling a small sample of copper is withdrawn and tested from time to time, because the quality is spoilt if it be overpoled, by the formation of a carbide of copper. The right point having been arrived at, the pole is withdrawn, the scum which has accumulated on the surface is skimmed off, and the metal is then lifted out in ladles lined with clay, and poured into the ingot moulds to cool. The cooling process is expedited by inverting the moulds over a bath of cold water, and letting the ingot of copper fall in, as soon as it is sufficiently solidified. The action of the water also imparts to the surface of the metal a slight bloom, which is valued in some markets.

Various processes have been invented at different times for simplifying those already described; but as a rule they have not maintained their ground against the old-established plan.

The principal novelty in one of these which was practised for some time, consisted in the removal of the arsenic, tin, antimony, and other metallic impurities, by converting them into soluble salts by fusing the calcined ores with the addition of some soda ash. The contents of the furnace are subsequently put into tanks of water, when the foreign matters dissolve out, leaving the sulphide of copper in a finely-divided state, which is then ready for the second calcination.

Another modification depended upon the conversion of the sulphide into a sulphate, which is readily soluble in water, so that the metallic salt could be dissolved out, leaving the whole of the earthy matter behind. From this solution the copper is easily separated by the agency of iron, the latter taking the place of the former, and becoming converted into a sulphate, while the copper is deposited in a metallic state. It is necessary, however, to brush the copper off the sheets of iron from time to time, or the deposit would soon become so thick as to check any further action. The copper then only requires refining. The result is a very pure and highly malleable metal; but the necessity of grinding the ore in the first instance preparatory to converting it into a sulphate, and the loss of iron in precipitating the copper, have prevented its adoption on a large scale.

The greater affinity of the sulphuric acid for the iron over the copper, led to the adoption of this reaction at the works of the Great Parys Mine in Anglesea. The water from the dressing floors, as well as that pumped up out of the mine, became so highly charged with this copper salt that it was found well worth while to carry it into large reservoirs for the purpose of precipitating the metal. Iron plates were immersed in the liquid, and the copper deposited upon them was brushed off daily, until the iron was so far eaten away that fresh plates had to be substituted for the old ones.

In Germany, Sweden, Russia, and France, where oxides and carbonates of copper are more common, the smelting process is often simpler, and blast-furnaces are frequently used instead of those made on the reverberatory principle, which are alone adopted in England. As the foreign plans are not equally applicable to the prevailing character of the English ores, it will be unnecessary to go into these in detail.

In Chili, and some other foreign parts, the ore is very frequently converted into regulus on the spot, and sent in this condition to Swansea, to undergo the final operations. The carriage of a considerable per-centage of useless gangue is thereby saved, and the ships which bring the regulus to this country take out the coals which are to be used in the reduction works at the mines.

BUILDERS' QUANTITIES AND MEASUREMENTS.—IX.

BY E. WYNDHAM TARN, M.A.

JOINERY AND IRONMONGERY.

ALTHOUGH the joiner works in a similar material to that used by the carpenter, yet the character of his work is very different, requiring another class of tools, which must be used with greater care, and more finish is put upon the material. And whereas the carpenter's work is mostly executed out of doors, that of the joiner is always done in a workshop or close shed, so as to be unaffected by weather or change of temperature.

The work of the joiner consists in the framing and hanging of doors, shutters, and sashes, laying floor boards on the joists fixed by the carpenter, framing and fixing wooden stairs, hand rails, and balusters; putting skirtings and dados round the rooms, framing and fixing wainscoting or other framed work, and all the internal fittings and decorations which have to be made of deal, oak, mahogany, or any other wood.

The joiner has also to fix the ironmongery, as locks, hinges, bolts, knobs, screws, latches, etc., upon his work, and for this reason the ironmonger is always taken with the joiner in measuring, the several articles of that trade being numbered as each part of the joiner's work is measured, and afterwards brought into bill at the end of the joiner's bill as "ironmongery and fixing."

It is usual in measuring joiners' work to consider that the materials and labour are taken together and charged at one price; but there are cases when the materials are found by one person and the labour by another, in which case the work is taken as "labour only and fixing," or as "labour, nails, and fixing," which latter includes glue, nails, and everything except the raw material. In measuring joiners' work no allowance is made for tenons, the superficial area of any framing being exactly measured, and its character and thickness described fully. If the work is less than 4½ inches wide, it is usual to take it by running measure, describing thickness, width, and labour upon it. Small or ornamental works, that cannot be measured, are numbered and described.

In measuring the floor of a rectangular room, take the exact superficial area, adding the area of all recesses or irregular pieces. If the sides of a recess are on the splay, the area of the piece of flooring must be taken by its greatest length, as if rectangular, or the nett measurement may be taken, and the splays measured, their length by a width of 3 inches for an addition to the superficial measurement, or else as run of cutting to splay. If the room is not rectangular, a proper allowance must be made in taking the dimensions, and all cuttings measured as above described. The space occupied by the hearths of fireplaces is not generally deducted from the measurement of the floor, unless there is a mitred border round the hearth, in which case deduct the area of the hearth, and measure the mitred border by the foot run as extra.

The material, thickness, and mode of construction of the floor must be described, whether deals, battens, or wainscot, the thickness as ¾ inch, or "three-cut," 1 inch or "two-cut," 1¼ inch, etc.; whether folding, straight-joint, with splayed or tongued headings, dowelled or tongued.

In measuring skirtings and dados first take the run of the skirting for the "grounds," describing the thickness and width, and if plugged to wall. Then take the length of the skirting, allowing for the angles, by the width, as superficial measure; describe the thickness, width, character of moulding, with backings, whether straight, raking ramped, or circular; if scribed to stone steps, plugged, rebated to form double plinth, writhed, or otherwise. Number all mitred or tongued angles, housings, etc.

Where deal, oak, or any other wood is used in joiners' work of uniform thickness throughout, its superficial area is taken, the thickness stated, and the workmanship described, as wrought on one or both sides, framed or clamped, matched and beaded, dovetailed or keyed, ploughed and tongued, staff-beaded, ledged, etc. If the ends are mortice-clamped, take their run, and number any mitres. All bearers, fillets, slips, etc., are taken by the foot run, describing their dimensions, and if chamfered, beaded, grooved, rebated, etc.

Framed partitions formed into panels are measured nett by the superficial foot, describing the thickness, and whether square framed, moulded and square, that is, with a moulding planted on one side only of each panel, bead-butt and square, bead-flush and square, moulded or beaded on both sides. Spandril framing having a raking top-rail, is measured nett and described as such; if circular or curved on plan, describe the sweep of the curve.

All doors are measured by the superficial foot, taking the nett height and width; folding doors must have the rebate on each leaf measured in taking the width, state the thickness, and describe whether ledged or braced, giving the size of the ledges and braces, and if wrought, tongued, or beaded; if panelled, whether plain "square," that is, without mouldings to the panels, moulded on one side and square on the other, bead-flush or bead-butt and square, moulded both sides, moulded and bead-flush, or otherwise. If the moulding projects beyond the face of the rails, describe as bolection moulded. State the number of panels in each door. All hinges, bolts, locks, knobs, furniture, to be numbered and put under the head of ironmongery.

In giving the thickness of doors or other framing it is usual to state the thickness of the rough wood out of which the styles and rails have been got, and not the finished thickness; thus a 2-inch door really finishes little more than 1¾ inches.

The linings to which inside doors are hung are measured superficial, taking the nett length as seen in the opening, and adding thereto four thicknesses of the linings, by the nett width. Describe the thickness, whether single or double rebated, beaded on one or both sides, framed in panels, and if circular. The grounds on the outside of the door linings are taken by the foot superficial, their nett length round the outer edge, adding twice the width thereto, by the width; state thickness, and whether beaded or otherwise worked; the labour in this case will be only on one side, the back being left rough. The architrave mouldings round the grounds are taken by the foot run, measured round the outer edge, and adding twice the width to the running dimension; describe the thickness and width. If there is a moulded cornice over the door, take its girt by its length as superficial measure, adding extra measure for the mitres.

In measuring outside or entrance doors the frames, if solid, double rebated and beaded, are taken as "cube proper doorcase," as described under "Carpenter;" the fanlight is measured separately by the foot superficial, describing its thickness and the character of its mouldings, and if circular or square headed. If the doors have circular or curved heads, measure the straight part in the usual way, and take the circular part as if square, describing it as circular.

Sash doors, having the upper panels prepared for glass, are measured in the same way as other doors, and stating whether with diminished styles. In measuring doors that are circular on plan, either the nett measure can be taken and described as circular on plan, or an allowance can be made in taking the width of one and a half for a flat sweep of ¼ inch to the foot, double for a quick sweep of ½ inch to a foot, two and a half if a sharper sweep than the last; they can then be classed as straight doors. Also in measuring circular-headed doors, if the circular part be taken three times, or four times for elliptical or gothic, the superficial measurement can be added to that of the square-headed doors of similar character.

Wooden gates are measured by the foot superficial, describing thickness and construction, whether open bars, cross bars, chamfered, panelled, etc.; number and describe all the iron-work thereto.

Closet fronts are measured by the foot superficial, deducting the opening for the doors, and measuring them separately. If curved on plan to a flat sweep of ¼ inch rise to the foot, add one-third to the width in measuring; if a sweep of ½ inch rise to the foot, add one half, and then they can be taken as if straight; or else take their net measure, the height by the girt, and describe the sweep. The closet tops and shelves are measured separately by the foot superficial, the architrave moulding, fillets, and pin-rails being taken by the foot run, numbering the pins. Narrow deal or mahogany skirting round the top of dwarf closets is taken by the foot run, numbering any dovetail angles.

Shop front and counter enclosures are measured by the superficial foot, taking circular parts in the way described above for closet fronts. Friezes and cradling to shop fronts are taken by the foot superficial, describing the cradling whether with ploughed and tongued blockings, and the frieze as keyed, feather-tongued joints, etc.; circular work being measured as above described.

Sliding sashes are usually measured by the foot superficial, including the cased frames, oak sills, lines, pulleys, weights, etc. Take the height from the under side of the sill to the top of the head, and the width in the clear opening with 9 inches added on. Describe the thickness of the sashes, whether single or double hung, the character of their mouldings, the sort of pulleys, lines, and weights used in hanging them; whether with oak sill, single or double sunk, weathered or throated; and state any peculiarities in the form of the window. Number the sash fastenings. If the sashes are curved on plan to a flat sweep of ¼ inch rise to the foot, measure the girt one and a half times, and multiply by the height as before; they can then be placed among the straight windows; if the sweep is ½ inch rise to the foot, take double the girt by the height; or the nett measurements can be given and the sweep described, the items in that case being kept separate from the straight.

Casements hung to solid rebated frames are measured in the same manner as sliding sashes, including the whole of the frame in the superficial measurement, and describing the sills, frames, and casements. If circular on plan allow as before, or else take nett girt and describe. The frames may also be taken separately, and cubed as solid frames, the casements only being measured superficial.

Skylights are measured superficial, taking the length by the width, and describing as ovolo, chamfer bar, astragal, etc., and whether rectangular or irregular on plan. If hipped, take the run of the hips as extra upon the superficial measurement. Curbs in two thicknesses to circular or elliptical skylights are taken by the foot run.

Venetian frames and sashes, with solid or cased mullions, are taken separately from ordinary sashes, but measured in the same way.

In measuring window backs and elbows, take the height from the floor to the under side of the beaded capping by the length, allowing for the passings at the angles, and the capping by the foot run. Number the caps of the elbows. The soffits are taken by their superficial area, but if the ends are splayed, measure the greatest length by the width. If the work is circular, take the girt one and a half times for a flat sweep, and double for a quick curve; it can then be abstracted with the straight work; but if measured nett it must be abstracted separately.

Grounds round windows are measured by the superficial foot, the length being taken round the outer edge, the thickness and labour thereon being described. Architrave mouldings are taken by the foot run when less than 4½ inches in girt, all mitres being numbered. Large mouldings by the foot superficial, the length by the girt.

Folding shutters are measured the same way as folding doors, allowing for the rebates; the back-flaps are measured separately if there is less work upon them. Describe the thickness and number of panels in height, and how finished; number cuttings for shutter bars, as well as all ironmongery. When the shutters fit into boxings, measure the boxings and back-linings by the foot superficial, stating the thickness, and whether they are rebated, beaded, or on splay, and if the back-linings are plain or framed. Number the soffits and boxings and also the elbow caps.

Sliding shutters, hung with cords and balance-weights, are measured by the superficial foot, stating thickness and describing the number of the panels and the labour upon them, lines, pulleys, and weights. Run the grooves and the flap for covering the top of the shutters when let down.

Outside folding shutters are measured same as those for the inside, the hanging style being taken by the foot run, or else measured in with the area of the shutters.

In measuring coiled shutters, whether of wood, iron, or steel, the superficial area is taken, with an allowance of 2 inches in width, and from 9 to 12 inches in the height; this is for shutters coiled at top or bottom. If coiled horizontally, allow 6 inches in height, and 9 inches in length.

In measuring the fittings of the water-closet, take the superficial of the seat and riser, describing the mode of fixing and thickness, number the dished hole, beaded hand-hole, and all rounded corners. Run the moulded nosing to seat. Take the area of the flap and frame, describing the thickness and labour thereon. Run the skirting round seat if narrow, numbering the mitres. Angle shelves, boxes, etc., in corner of water-closets, can be numbered.

Wooden staircases are measured by the foot superficial, taking the girt of treads and risers to the flyers by the extreme length of the tread; describe the material, thickness of treads and risers, whether glued, blocked, and bracketed, the number and scantling of the carriages, and if with returned moulded nosing to the treads, if cut and mitred to string, housed to string, etc. The curtail or other kind of end to bottom step to be taken separately. If there are winders, measure the nett area of treads and risers, including the nosings; grooving and tongueing by the foot run. Number the housings, the circular ends of nosings, circular cut brackets, etc. Number the dovetailed sinkings for balusters. Take the run of each baluster, describing their thickness and workmanship. Iron balusters and newels to be taken separately in the same way. Handrails are measured by the foot run along the middle, the parts that are circular, ramped, or wreathed, being measured separately from the straight. Take the run of sinking for iron core, the number of the handrail screws, the number of scroll or other ends, moulded caps, screw nut and joint, etc.

The strings into which the treads and risers are framed, as described in Article XIX. on "Building Construction," are measured by the superficial foot, taking the length out and out by the width, describing their thickness, if framed, rebated, beaded, sunk, or moulded, cut and mitred to risers, wreathed or circular. The measurement of ramps and wreaths is to be kept separate from the straight work. All tongued angles, housings, splayed ends, etc., are to be numbered. Cuttings and ramps to wall-strings are taken by the foot run, describing whether plain, circular, moulded, rebated, or reeded.

Apron linings, fascias, etc., are to be measured by the superficial foot.

Beaded or square angle-staff plugged to external angles of rooms is measured by the foot run.

Take the run of narrow window bottoms or nosings, numbering the rounded or returned ends. Number all rounded ends to shelves, notchings, or other small cuttings.

The sashes of shop-fronts can be taken by the foot superficial when the squares are of moderate size and all of wood, the circular parts being measured separately. But when there are few or no intermediate bars, or if brass sash bars are used, they should be taken by the foot run, describing the size of each bar and its design. Angle-bars, beaded stops, guard or angle beads, are taken by the foot run when the sash is measured superficial.

Pilasters and columns, when imitated in wood, are measured by the superficial foot, the height by the girt, stating the diameter of the columns, and whether straight, diminished, or curved. The caps and bases are numbered. Grooves and flutings are taken by the foot run, describing the diameter and form of section; the stopped or turned ends to fluting are numbered.

In abstracting the joiners' work all the various thicknesses must be kept in separate columns under heads of "rough," "wrought one side," "wrought two sides." Work that is measured by the square has a separate column from that which is taken by the foot. Shutters, doors, sashes, and frames, mouldings, runs, and numbers will all have distinct columns.

In abstracting the ironmongery, form separate columns for hinges, bolts, screws, door springs, locks, knobs, fastenings, etc. keeping the different sized hinges, locks, bolts, etc., separate one from the other. The hinges are always taken in pairs, except swing centres or spring hinges, which may be taken singly. In numbering the locks a full description of the size and quality must be given, together with the kind of furniture belonging to them. Small articles, as mahogany knobs, brass hooks, shutter lifts, are taken by the dozen. Shutter bars are valued by the inch in length; espagnolette bolts for French casements are taken by the foot, describing the diameter of the rod; but if under 5 feet they must be taken as 5 feet long.

SANITARY ENGINEERING.—XVII.

DRAINAGE AND WATER-SUPPLY.

MANUFACTURE AND ARRANGEMENT OF PIPES.

In two preceding papers we have been dealing with the broad question of water-supply for country districts and metropolitan neighbourhoods; and we now go one step further in detail to consider the manufacture of the pipes, with which, when the water is laid on to the house, it is carried to the various quarters required. In all high-class work these are almost invariably of lead, manufactured for the most part as under. We give a description of what is probably one of the most powerful machines now in work at a large well-known factory in Southwark. The power is that of an hydraulic press, and the one in question was specially made and actually used in fixing the tubes of the Britannia Bridge over the Menai Straits. Above is fixed the vessel that receives the charge of from two to four cwt. of lead in a semi-fluid state, supplied from a copper connected close by. When the charge is in the receiver, the plunger of the press gradually rises and presses the lead through a mandril at the bottom of the receiver, from which it issues as one continuous pipe, the size and weight of which is varied at will by the use of different mandrils. It will be seen at once what an immense length of ordinary pipe is obtainable without joint by this process. In practice, however, it is usual to cut the pipe off in lengths of sixty feet, for convenience of stowage and transport.

The action of some kinds of water upon lead pipes is very destructive, and the cases of lead poisoning that we hear of arise from this cause. As a general rule hard water is much less destructive than soft, as the calcareous or similar matter with which the water is charged stops corrosion at a certain point by forming an insoluble coating, which prevents further decay; while the soft water dissolves and washes away coat after coat, which it holds in solution with the worst effect, especially if the water has been in contact with the lead for some considerable time.

When the water is of this nature iron pipe properly protected from rust may be used, and we may mention, as the best preparation that has come under our notice, a solution invented by Dr. Angus Smith. It is of a bituminary nature, and if applied when the pipe is thoroughly clean it is perfectly efficacious; as pipes thus treated have been examined after fifteen years' use, and found as perfect as when first laid down.

And here we may note the great advances that have been made of late years in the manufacture of iron piping, and recommend its adoption with proper precautions in place of lead. Thirty years ago wrought-iron pipe of ordinary dimensions was not made, but now it is a very extensive branch of manufacture, especially at Birmingham. It is manufactured by passing plates of iron at welding heat through rollers specially constructed for the purpose, which at the same time produce a pipe perfectly true, and form a sound longitudinal joint. Pipes thus manufactured may be made to almost any required strength. It is not uncommon, when required for hot water or steam purposes, to have them tested up to 3,000 lb. pressure to the square inch. They are very much cheaper than lead, though not so easily fixed, for this reason, that the lead can be beaten cold to almost any required angle, and bent as necessary, whereas it is requisite for bending that iron pipe should be heated in a forge. Custom has much to do with the matter. Iron pipes are constantly used for the laying on of gas, and there is no practical reason why they should not be used in the same way for water. Though it is very rarely done *inside* the house, *outside* iron is in almost universal use. The mains of the companies are all of iron; and if an engineer is called in to lay on the water to a mansion in course of erection, or to arrange a village or town supply, he invariably uses iron pipe throughout, until the interior of the house is reached, then the plumber steps in, and lead, a far more expensive material, replaces the iron that has done the work so far.

An invention has been recently brought out, which provides effectually against the corrosive action of soft water upon lead. By a patent recently taken out by a Mr. Haines, pipe is manufactured by a process somewhat similar to that above described for lead, in which that material is provided with an inner coating of tin. It is called "Haines' Patent Lead Encased Block Tin Pipe," and the process of manufacture is so perfect that it can be bent, handled, and manipulated with the same facility as lead, than which, however, it is considerably stronger. It has been submitted to Dr. Letheby, Dr. Lankester, and other authorities of unquestioned weight, and has their distinct approval from a sanitary point of view; and we append the result of some experiments made by Mr. Kirkaldy's well-known testing apparatus on the question of strength.

In the course of July of this year (1871) Haines' half-inch pipe, weighing per yard 4·917 lb., burst with a pressure per inch of 1,859 lb. Half-inch common lead, weighing 7·130 lb., burst with 1,579 lb. Haines' two-inch, weight 16·406 lb., burst with 642 lb. per inch. Two-inch common lead, weighing 27·967 lb., burst with 498 lb. The pipe is more expensive than ordinary lead, but its extra strength enables us to use a less weight of pipe in proportion, and thus its extraordinary hygienic advantages are attainable at no greater expense than that entailed by the use of the commoner material. It should be borne in mind also, that lead should never be used when hot water is in question; the heat of water approaching the boiling-point expands the pipe beyond its power of contraction, distortion is the inevitable result, and in course of time, fracture and failure. If any further argument were wanted to show the comparative advantage of iron over lead for ordinary water-supply, the invariable use of iron pipes for all purposes connected with warming by water, of which we have given full details in some previous papers, may be taken as conclusive upon this point.

A fruitful source of inconvenience arises when lead pipes are laid under the pavement from the main to the front wall of the house, passing in many cases over the cellar under the street. In case of any repairs or alteration, it is a common accident that a small hole should be cut in the pipe with a sharp point of a labourer's pick, the pipe being still underground, and the man unconscious of the mischief he has done. The paving work being completed, the workmen leave, and the leak continues, and is only discovered when the whole of the earth above the cellar arch is saturated with water; and the brickwork of the arch being in the same condition, the damp makes its appearance on the inside, and leads to the necessary investigation. Cellars previously fit for the storing of dry goods, once thoroughly saturated in this way, are not fit for use again for the same purpose for many months.

In laying on water where the intermittent system is in use, as in the London districts, it is of great importance that the service be large enough to fill the cistern in a space of time considerably less than the hours during which the water is on. The usual system is to have the cistern provided with a ball-cock—*i.e.*, a cock which is turned by an arm, at the end of which is an empty copper ball, which must be air-tight; this is self-acting, for, as the water rises, it turns off the tap and closes the supply, any surplus passing off through the waste-pipe or overflow. This pipe usually enters the cistern at the bottom, and should always be considerably larger than the supply or service pipe, so that in case of any accident interfering with the action of the ball-cock the superfluous water may pass down the waste to the drain, instead of overflowing in the house. The usual course is to screw into a brass union at the bottom of the cistern what is usually called a "trumpet waste," of the exact height of the contained water; the narrow end of this is screwed into the bottom, and the upper end opens out in a trumpet form about three or more inches in diameter, to allow of a ready escape of overflow water; when the cistern has to be cleaned out this can be unscrewed and the cistern emptied and thoroughly washed, the water in this case being drained from every part.

Another common source of trouble and damage in water-supply is frost. In an unusually severe winter it is not uncommon for half the houses in a street to have the water frozen in the pipes; the natural expansion that takes place when the water is frozen bursts the pipe, but the mischief is not apparent until the thaw comes, when of course the house is deluged. This may be obviated in various ways, by a careful arrangement of the supply-pipes, so that no portion of them shall be exposed to the external air, and that if possible they may for the greater portion of their course run up along the side of a flue in constant use.* Sometimes an arrangement has been made by which in cold weather a small gas-jet maintains a slight warmth at a certain part of the pipe, which in this case must be iron. This affords a sufficient protection to the general supply, but is not usually done nor generally understood. In the course of last winter one house in a street in a first-rate West-end neighbourhood thus provided was the only one that maintained its supply uninterrupted throughout the winter. Nothing is more common in suburban districts than to see the supply-pipe outside running up to the cistern which forms a portion of the roof of some back building. When this is the case, failure in case of frost is a certainty; and the only method of protection from freezing, fracture, and subsequent flooding is, the moment the frost becomes sufficiently severe to threaten the pipes, to have the water turned off at the main, and then *empty the pipes* by letting all the water run away from their lowest point; the supply will in any case be stopped by the frost, but by adopting this precaution all risk of consequent damage is avoided. In all grouped buildings—such as the model-lodging houses, now becoming so numerous, and the sets of residential chambers, every year coming into fashion—unless some artificial means of warmth are adopted for protection, this course should invariably be adopted. We may mention that at the immense groups of chambers in the Temple, some of ancient and some of modern construction, where the water-supply is of course very various and complicated, this precaution of emptying the pipe in case of hard frost is invariably adopted with success.

Having thus dealt with some details of the manufacture and arrangement of pipes, we shall in our next paper take up some similar questions as to the manufacture and material of cisterns; and then proceed with some of the details of what we may call internal systems of plumbers' work, giving particular attention to a point which does not usually receive sufficient notice—*i.e.*, the ventilation of the pipes.

CHEMISTRY OF THE FINE ARTS.—VI.

By Professor CHURCH, Royal Agricultural College, Cirencester.

PRESERVATION AND RESTORATION OF PAINTINGS IN OIL—OIL PAINTING—PAINTING WITH WAX AND PARAFFINE.

THE method of silicious painting described in our last paper is that which has received the most extended trial, and has led to the most successful results. Not only, however, does it admit of improvement, but it is quite possible that some other process of painting based, like it, upon the employment of a chemical product, may ultimately replace it. Already many suggestions in this direction have been made. A mixture of potassium silicate and potassium aluminate in solution has the property of spontaneously solidifying after a time, and may be used with pigments to fix them on a prepared surface. The silicate is to be of specific gravity 1·2, and the aluminate of specific gravity 1·12. A solution of phosphoric acid, or of monocalcic phosphate may be similarly employed upon any ground with which baryta, lime, or lime compounds have been mixed. Until these methods, and others which we could name, have been submitted to further experimental proof, it will suffice for us to name them here, with the expression of a hope that some artist of eminence will try their merits.

In speaking of the chemistry of oil painting, it will be judicious to introduce a few words in the first place upon painting-grounds. It is of the very first importance that the canvas, panel, or millboard on which a picture is to be painted, should present certain characters of permanence. Canvas made from hemp or linen is in its nature liable to a daily alteration of weight and size, owing to variations in the amount of hygroscopic water or moisture which it absorbs or retains. Unprimed canvas may contain on a dry day 5 per cent. of water, and on a damp day 11 or even 12 per cent. By saturation of the canvas with some water-repellent material, such as oil, wax, or paraffine, the variation we have named may be almost entirely prevented. A solution of paraffine in mineral turpentine, or of copal varnish in ordinary spirits of turpentine, or a mixture of these two liquid preparations, may be used to saturate a canvas or a mill-board before laying the priming or ground upon it. The canvas, etc., should be carefully and slowly dried, at a temperature not exceeding that of boiling water, before saturation with the waterproofing liquid; and of course an equally thorough drying is necessary afterwards, before the priming is laid on. It is difficult to treat panels in the same way, but if they are of well-seasoned wood, and their back and front surfaces are of equal age—that is, have been equally long exposed to the influence of the air, the best mode of preventing their warping and cracking is to charge the back of the panel with as heavy a coat of paint as that which the finished picture on the front may be presumed to contain. The saturation of canvases, panels, etc., with any preservative solutions such as those named above, may be best accomplished by their immersion in the prepared liquid in a chamber partially exhausted of air. On re-admitting air, the liquid fills the pores of the material much more completely than is the case where it is merely painted over the surface. To saturate ivory with paraffine, etc., previously to painting upon it, is quite easy if the ivory be immersed in a vessel of melted paraffine, and then placed on a heated iron or brick, under the receiver of the air-pump. It has been[*] recommended "to steep the canvas before painting in a solution of silicate of potash. If the canvas is steeped in this solution and carefully dried, and then stretched and painted, it will preserve its soundness for many years, the silicate acting as a protective covering to the fibres of the hemp of which the canvas is made.". It is impossible for any one who has studied the action of soluble silicates upon vegetable fibres, either in the case of tent or picture canvas, to join in this recommendation. With a potash water-glass as free as possible from excess of alkali, it will be found that the fibres of the canvas will be—firstly, discoloured, and the discoloration will find its way through the ground to the picture; secondly, that the fibres will be seriously weakened; and, thirdly, that they will be rendered still more hygroscopic than before. If any preparation of silica be selected for trial, we should suggest the use of a solution of pure silica in water, prepared by Graham's method of dialysis; but although direct experiments do not tend to show that such a preparation is of much use for the improvement of canvases, it cannot discolour or weaken them. We shall have to recur to this subject presently, in speaking of the preservation and restoration of paintings in oil.

A bad practice of priming and grounding canvases with size and whiting is very general. This preparation, however well it may stand in a dry climate and pure air, is not permanent under the atmospheric conditions of a modern English city. Nor is the free use of plaster of Paris in grounds a safe employment of this substance. Although such grounds as these may adhere strongly to the canvas at first, they often become loose after the lapse of some years, and crack in all directions. There is, in fact, a certain degree of incompatibility, as it is called, between the material and medium of the ground on the one hand, and the medium of the subsequent painting on the other. Unequal contractions occur, while the ground and painted surface alike become fissured. A really good ground may, however, be made by means of white lead ground in oil, and mixed with a little pure, pale picture copal. Upon this surface, while it is still tacky, dry and warm zinc white should be dusted. This will adhere in part, and form a dead white surface, very suitable for throwing brilliancy into the subsequent layers of colour.

We have before spoken at length of the pigments and media used in oil painting, and we have here but to add some details as to the modes of using them—so far at least as chemical actions are concerned. Now, when we recall the ingredients of the various media used in oil painting—oils, resins, turpentine, essences, with, in some cases, wax and paraffine—we shall see that the change of conditions from a soft state in which the pigment may be laid on in fine lines with a brush, to a state of very considerable hardness, is brought about by two actions going on in the media. One of these actions is the evaporation of the essential oil or spirit, the other is the absorption of oxygen. Both actions tend in one direction, the hardening of the cement which binds the particles of the pigments to each other, and to the painted surface. But it is evident that neither the evaporation of the volatile part of any medium nor the oxidation mentioned above can proceed properly if the ground be not thoroughly dry before the first layer of paint be placed upon it; and so on with each successive addition of pigment. A good rule deduced from this observation is to make a point of employing the most rapidly drying medium first, and afterwards, if any change be made, it should be in the direction of a slow dryer. By using a variety of oils, and megilps, and varnishes, some rapid and some slow in drying, and some disinclined to dry at all, the most fatal results ensue to the coloured films which constitute the picture, and which are pulled about and torn in all directions. If copal varnish, with poppy or linseed oil, be the medium in use, then in the later paintings more oil and less copal should be employed. Further, six months at least should elapse before the finished painting be varnished, the varnish itself being thinned suitably and laid on rapidly, evenly, and lightly. Before each successive painting, and before varnishing, it is often necessary to adopt some plan of preventing the new coat from "rolling," as it is termed, in beads or drops, instead of becoming smoothly distributed over the last painting. To moisten the previous layer with saliva is a usual but a reprehensible practice. It endangers the safety of the new film of paint, for water subsequently applied to the painting may penetrate to the residual matter of this saliva, and dissolving it away, loosen the coloured film above it. Sponging the unfinished picture first with a weak solution of ox-gall, and then with distilled water, is a far more satisfactory way of cleansing it and preparing it for subsequent painting or varnishing. Or the painted surface may be exposed for a few minutes in a box, to air charged with alcohol vapour.

The common practice of "laying in" a work intended to be completed in oil with water-colours is most unsafe. Exactly the same objection applies to it as to the use of saliva just described, only in a tenfold degree. Some painters, however, go so far as to paint with water-colours mixed with a little ox-gall many of the minuter details and rich glazings of their pictures, trusting sometimes to a little oil or varnish to keep these water-colours in their places. Possessors of pictures thus made up will sooner or later discover the ill effects of such tricks. Fissures will form, changes of tint take place, and if the picture be at any time submitted to any of the common cleaning and washing processes, the rich and delicate water-colour work will be wholly carried away, taking with it, it may be, many a thin glazing or scumbling in oil, precious from an artistic point of view, but held in its place by a too precarious tenure.

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[*] Professor Barff: *Journal of the Society of Arts* (1871), Vol. XIX., page 158.

We have hinted, in former papers, that it is possible to make certain changes for the better in the media of oil painting. The following substitutions are amongst those which promise well. For turpentine and other essential oils liable to resinify and darken, use benzole and toluol—hydrocarbons abundantly found in coal-naphtha. For the fixed drying oils, substitute, wholly or partially, the purest paraffine or hard white beeswax. For mastic and dammar varnishes, substitute the best sort of pale copal varnish. These alterations must be made with judgment, and according to the purposes for which the medium is desired. In mural decorations, more particularly, advantages will accrue from the substitutions just named. For such a purpose the pigments must not present a heavy appearance, nor must the finished work show any surface gloss. The following recipe enables us to prepare a mural medium of great permanence and very easy working:—

Melt four ounces by weight of pure, hard, white paraffine, in a tin can or glass flask standing in hot water; then add, very slowly, eight fluid ounces of benzole, toluol, or the mixture of hydrocarbons contained in light coal-naphtha, boiling between 80° and 120° C. Then, still keeping the flask in hot water, add twenty-three fluid ounces of pure copal varnish, and thoroughly mix the contents of the vessel. In this formula pure white beeswax, which has been granulated by pouring it into cold water, and has then been washed in methylated spirit and again melted, may be substituted partially or wholly for the paraffine. So, too, oil of spike lavender, or even spirits of turpentine, may be used instead of the coal-naphtha. The copal varnish is best made as directed in Article III., using the white, hard, Sierra Leone copal resin if possible. This medium presents great resemblance to a wax medium which was recommended some years ago for mural work by that distinguished painter, Mr. Gambier Parry, of Highnam Court, Gloucester. This amateur artist has executed some noble works in a preparation containing wax, resin, elemi, oil of spike, and copal varnish. Some of the best and latest of these decorate the walls of St. Andrew's Chapel, in the Cathedral of Gloucester. Others, which have stood well several years, are in Highnam Church. In Mr. Parry's process, as in all other processes of a similar kind, the wall should be prepared with a pure fresco ground, allowed to become quite dry and hard; but a coarse sand is not advisable, as the pigments may be rubbed off from the prominences made by these grains. The wall to be painted should be saturated with a mixture of the medium employed, and some liquid solvent, such as the essential oils or hydrocarbons used in preparing the medium. When this is dry, the pigments, ground preferably in the medium rather than in oil, are laid on in the usual way. If it be desirable to thin the medium, it may be done partly by warming the tube or can holding it, and partly by adding some one of the fluid solvents just named.

There is one subject connected with the practice of oil painting which demands a few words of remark here. We refer to the varying amounts of oil which different dry pigments require, in order to bring them into that condition in which they may be used by the artist. The variations are so great and show so distinctly how much *binding material* one colour requires and how little another, that a list of the chief results of Herr Wurm's investigation of the subject may prove practically useful. This experimenter finds that—

100	parts by weight of	white lead	require	12	parts by weight	of oil.
,,	,,	zinc white	,,	14	,,	,,
,,	,,	chrome green	,,	15	,,	,,
,,	,,	chrome yellow	,,	19	,,	,,
,,	,,	vermilion	,,	25	,,	,,
,,	,,	colcothar	,,	31	,,	,,
,,	,,	madder lake	,,	62	,,	,,
100	parts by weight of	yellow ochre	require	75	parts by weight	of oil.
,,	,,	terre verte	,,	100		
,,	,,	Prussian blue	,,	112		
,,	,,	bone black	,,	112	,,	
,,	,,	cobalt blue	,,	125	,,	
,,	,,	burnt sienna	,,	181	,,	
,,	,,	raw sienna	,,	240	,,	

There are two sets of conditions which have to be considered in reference to the preservation of cabinet and gallery pictures painted in oil. One set of conditions has reference to the materials themselves of the picture, the other to its atmospheric and other surroundings. When the canvas, etc., the ground, the medium, and the pigments are satisfactory, the picture is still liable to injury from alteration in the size and form of the canvas or panel—alterations which may arise from excess of dryness as well as of damp, or from inequality of temperature. With the canvases of pictures, as ordinarily prepared, extreme dryness* of the air is as much to be dreaded as extreme damp. If a stream of warm and dry air enters a gallery just below the pictures, the canvases, frames, and panels become altered in shape and size each day, returning more or less to their original state each night. Thus the coloured films of the painting are submitted to an injurious strain, which may end, as the binding medium of the pigments becomes more brittle, in a multitude of minute fissures, and the final flaking off of portions of the paint. One day the canvas of a large picture may be tightly stretched; another day it may bulge out in an awkward manner. A panel may warp and even split from the same causes. A picture-gallery ought, then, to be kept at a mild and uniform temperature, and the atmosphere should be sufficiently charged with moisture to maintain the hygroscopic water of the canvas, etc., in its due and normal proportions. A registering thermometer will indicate how far the first condition is fulfilled; the realisation of the second may be estimated by a piece of primed canvas suspended in a light frame of metal from a delicate spring balance. The index of this balance will show the steadiness or fluctuation of the atmospheric moisture. And here we may suitably enter a protest against hanging pictures close to a wall, and against the ordinary plan of glazing pictures (in water as well as oil), especially where the range of temperature is great; the transference of water to and from the picture to the air-space in front of it and the glass exerts a most injurious effect upon the materials of the painting, and encourages the growth of minute vegetable organisms. And it may be further stated that the modes in which pictures are fastened into their frames do not permit with sufficient freedom of those minute movements which are inevitable, and the causes of which we have been at some pains to explain. It is scarcely necessary to say that air, impure from the presence of ammonia or sulphur compounds, or of coal-gas and its products of combustion, is most injurious to the permanence and preservation of paintings in oil. Air may be filtered through muslin, or even washed with advantage before it enters the gallery. So, too, the exclusion of soot and dust is of the greatest moment. A picture-gallery should never be entered except by means of passages and lobbies, where the dust which visitors bring in, or which the outside atmosphere contains, may be removed, or may settle. The floor should, for the same reason, be adapted to show dirt, not to harbour it. Projecting frames, and the inclining forwards of the upper part of the picture, will tend to prevent the lodgment of dust upon the painted surfaces.

A few notes on the restoration of pictures must not be omitted. Hitherto, the restoration of a clouded or damaged picture has too often proved to be its destruction as a work of art. The plan followed was the removal of the discoloured varnish by means of spirits of wine with occasionally certain additions of oil and spirits of turpentine, to modify the solvent action of the alcohol. As some amount of friction was employed in applying the liquid, delicate touches and glazings were often wiped out, so that the work of re-painting became necessary. But the method perfected by the German chemist, Dr. Max Pettenkofer, presents in many cases a great superiority over the former plan. It consists essentially in the exposure of the picture, previously washed with pure water, to the vapour of alcohol of 80 per cent. The operation is conducted in a closed shallow box, to the lid of which the picture is fixed, face downwards, and on the bottom of which a piece of flannel, moistened with alcohol, is firmly attached. All dust must be excluded throughout the operation, while the progress of the solvent action of the vapour on the varnish must be watched with care. In the case of pictures painted on canvas the process may be completed by spreading a thin layer of copaiva balsam on the back of the picture. But it would extend our lesson too much were we to enter into a full description of the several steps in the "regeneration" of pictures by Pettenkofer's method. For such details we must refer to a pamphlet,* in which the process and its results are fully given.

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* *Journal of the Society of Arts* (1871), Vol. XIX., page 158.

TECHNICAL DRAWING.—LXIII.

DRAWING FOR BRICKLAYERS.

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

Brick and Tile Paving.—Paving formed of bricks on their edges affords a much better floor, and is in some cases preferable to stone paving, if the latter be laid on the ground without the intervention of footings. Brick-on-edge paving in sand is generally used in beer-cellars, pantries, dairies, stables, etc., as its numerous open joints allow wasted or discharged fluids readily to escape, and it is both cool and dry under ordinary circumstances. In mortar or cement, bricks on their edge (Fig. 521) form a sound dry floor; the smallness of the surface exposed by each brick in this manner leaves them, of course, less susceptible of partial pressure, and the depth from the soil to the surface is such that damp rarely shows through.

The paving brick differs from the common brick only in thickness, its dimensions in that direction being 1¾ inch; it is, however, rather harder and more compact.

Dutch clinkers are paving bricks, smaller and much harder than the English; they are 6¼ inches long, 3 inches wide, and 1¼ inch thick, and are always set on edge and herring-boned—that is, instead of being placed in parallel lines, they are set at right angles to each other, as shown in Fig. 522, the face being kept perfectly even.

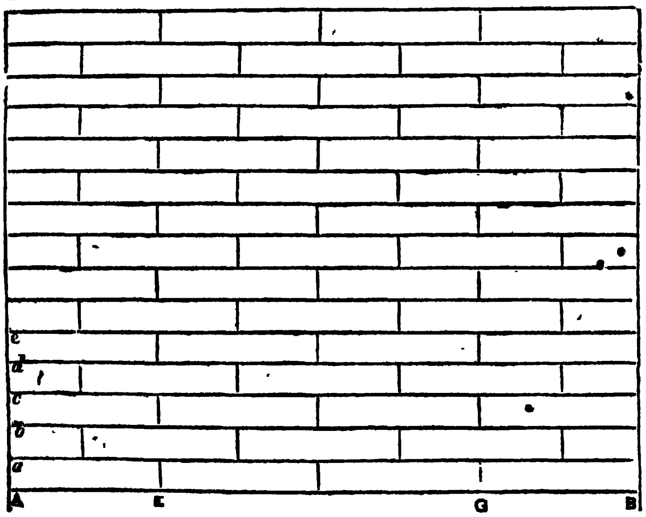

Fig. 521.

Common paving tiles are made 11¾ inches square and 1½ inch thick, and 9¾ inches square and 1 inch thick. These two sizes, however, are respectively called "twelve-inch" and "ten-inch" foot tiles. They are laid in courses as stone paving would be, the alternating courses breaking joint.

To copy Fig. 521, having drawn the lines A B and A C at right angles to each other, and having completed the rectangle A B C D, set off on A C the points *a*, *b*, *c*, *d*, *e*, etc., representing the widths of the *edges* of the bricks, and from these points draw lines parallel to A B.

These lines will give the separate courses, and lines drawn from points E, F, G will divide the first course into separate bricks, the length A E, etc., being nine inches by scale (the scale used in this subject is an inch to the foot).

The second course is placed so as to break joint—that is, the joints fall in the middle of the whole bricks adjoining. These two courses will serve as guides for all the rest, and the T-square having been placed so that its cross-head is guided by the left-hand edge of the board, the blade extending across it, the lines referred to are to be drawn with the set-square, guided by the edge of the blade.

Fig. 522 is a portion of a floor, executed in the manner called "herring-bone brick on edge." In commencing this, draw the line A B, and at any point in it, as C, draw C D at 45° to A B, which will be easily done with the aid of the set-square (of 45°).

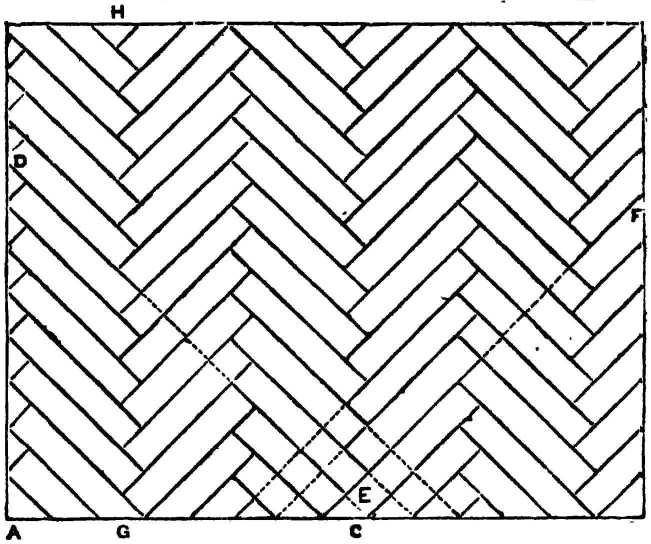

Fig. 522.

From C set off on C D any number of divisions equal to the widths of the side of the bricks. Through either one of these points, as E, draw a line at 45° in the opposite direction to C D, and from E set off to E F divisions corresponding to those on C D. The entire example is then to be completed by drawing lines through the points in these two lines, the whole being simply a chequer pattern, as shown at C.

It must be pointed out that the angles of the bricks must fall in straight lines at right angles to A B. This would be plainly seen if a line were drawn from G to H, and is a test which must be constantly applied during the progress of the work.

When the drawings have been inked they may be coloured. A few brief instructions on this head will be found further on.

Fig. 523.—This study is taken from a German pavement formed of bricks laid flat. It is used as the floor in a kitchen, and the bricks, which are 10 × 5 inches, are laid in cement.

The method of drawing this subject is very simple, for, since the bricks are doubly as long as they are wide, the whole surface may be divided into squares, two of which will make one brick. This floor is sometimes worked in black and red, and sometimes in red and buff bricks, in either of which it presents a very pretty appearance.

Fig. 524.—The pattern of this floor is formed of whole and half bricks, of the same size as those used in the last; and in copying it the surface should, as before, be divided into squares. The bricks used are black, red, and buff.

Paving in various stones seems to have been the origin of what has since been called "mosaic work." The fine effect and use of pavements composed of pieces of marble of different colours so well joined together as that when dried they might be polished, and the whole make a beautiful and solid body, which, continually washed with water and trodden upon, was not at all damaged, gave the painter the hint, and thus originated inlaid representations of borders, geometrical patterns, figures, etc. But the number of colours in marble being limited, variously coloured glass and even metals were employed.

This kind of work is supposed to have originated in the East, and was most likely brought from Phœnicia to Greece, and thence to Rome, where it was used principally for pavements. Many of these were exceedingly beautiful, and several excellent specimens have been found in this country.

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* "Über Ölfarbe," etc. Max v. Pettenkofer. 1870.

A very fine Roman tesselated pavement was discovered when digging to lay the foundations of the old India House (now removed), in Leadenhall Street, in 1803. This was as a whole square, with a circular disc in the centre, on the white ground of which was inlaid a figure riding on a tiger. This was surrounded by various borders, the principal of which was the ‘wave scroll.” The spandrils at each corner were filled in with vases, from the handles of which spiral scrolls diverged. Next came a square border of a chainlike character, and another filled with ornamental devices.

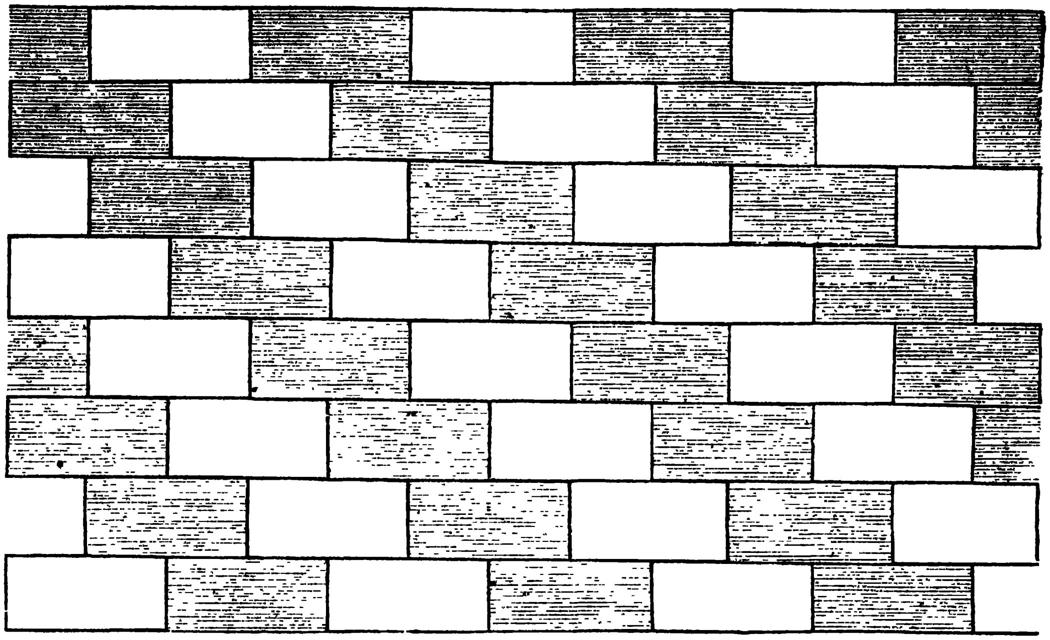


Fig. 523.

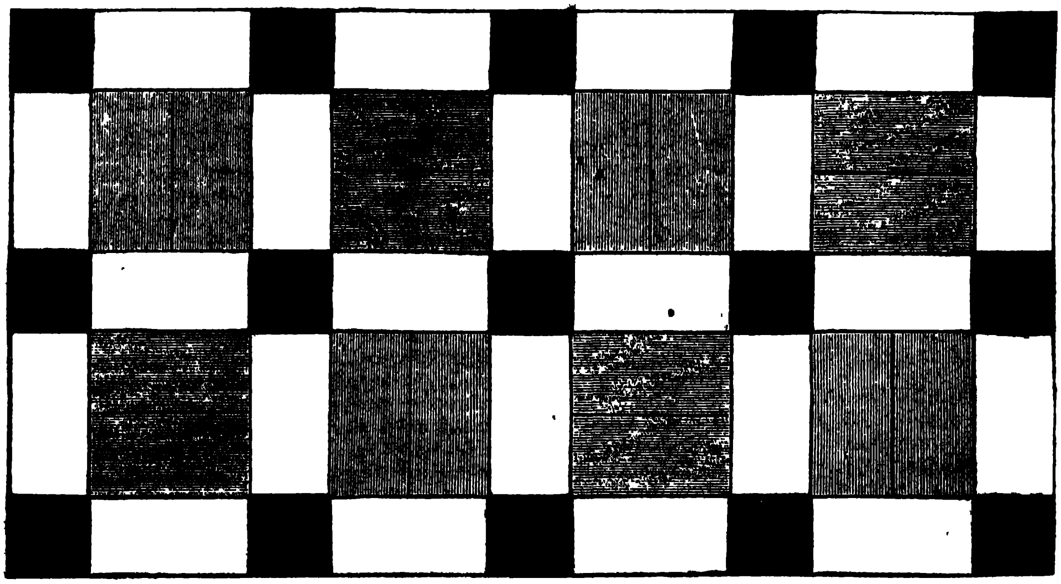


Fig. 524.

Another magnificent specimen was found in Somersetshire, in 1737, the general pattern of which was made up of numerous compartments filled in with geometrical devices, and the whole was surrounded by the Greek key or “fret” border; and a second pavement of a similar character was found in the same county in 1738, and only a few years ago a beautiful specimen was found in the Poultry, London. For accounts of several discoveries of remains of ancient work of this description, the reader is referred to the “Lessons on Mosaic Work,” in which several beautiful examples are figured.

As a rule, these pavements consisted, as in the first specimen alluded to, of borders surrounding a central figure or device, and sometimes a group or subject. Others consisted solely of patterns worked out in two or three colours, usually black, white, and red.

The material of which the mosaics of the Middle Ages were formed was chiefly glass, by which they are in a great measure distinguished from the Roman work.

Perhaps the nearest approach to manufacture is to be found in the rude inlaid work of the columns and fountains which were discovered in some of the gardens of the buried city of Pompeii. Mosaic work is also common in Arabian edifices, so much so indeed as to become a feature of the style. Their mosaics were principally of porcelain, and were employed in the decoration of the lower parts of the walls and also for pavements.

NOTABLE INVENTIONS AND INVENTORS.

XXVII.—JOSEPH BRAMAH.

BY JOHN TIMBS.

THIS celebrated mechanician was born on the 13th (New Style) or 2nd (Old Style) of April, 1749, at Stainsborough, in Yorkshire, where his father was a farmer well to do. He was the eldest of five children, and was intended for his father's occupation; but he very early indicated proofs of mechanical genius, and being at the age of sixteen incapacitated for agricultural labour by lameness, he was apprenticed to a carpenter and joiner. He next removed to London, where he worked for some time as a journeyman cabinet-maker, and afterwards set up in the same business for himself. He was led to that of an engineer or machinist by his invention of some very important improvements in the construction of water-closets, whence he became a manufacturer of those articles. His next important invention was the ingenious lock still known by his name, and which, after a lapse of seventy years, during which time many new kinds of locks have been introduced, maintains its character as one of the most inviolable locks ever contrived.

By far the greater part of the almost innumerable ingenious contrivances for rendering locks inviolable, may be classed under one of two systems of security. The first consists of the insertion in the lock of fixed obstacles, commonly called wards, which prevent the entrance or revolution of any instrument or key which is not formed with corresponding openings, so as to thread its way among them, and thus render the bolt inaccessible to any but the proper instrument; while the second consists in the use of movable impediments, which in their most general form are called *tumblers*, a term which, for convenience, we may apply generally to the motion of the bolt itself, the security arising from the difficulty of bringing these movable impediments, by the use of any but the proper key, to the actual and relative positions necessary to allow free motion to the bolts. It is curious to find that this kind of lock is of great antiquity. According to M. Denon (in whose magnificent work on Egypt it was published), from the circumstance of finding one sculptured amongst the bas-reliefs which decorate the great Temple at Karnak, it was ascertained that during forty centuries the lock had undergone no sensible change. (Ainger on Locks.) Notwithstanding the high antiquity of the tumbler principle, its first important application in this country appears to have been made by Barron, in 1774 or 1778. In the simple form of the tumbler there is the disadvantage that, while it effectually prevents the removal of the bolt unless the tumbler be raised high enough, it presents no obstacle to its removal when, by the use of a false key, the tumbler is thrown up beyond the proper degree. This defect is remedied in Barron's lock, and in many more recent contrivances which are based upon it, by the use of several tumblers, each of which requires to be raised to a different degree, and any one of which, if lifted too high, will form as effectual a barrier to the motion of the bolt as if it were not lifted at all.

Bramah's lock was invented and patented in 1784, when he pronounced it "not to be within the range of art to produce a key or other instrument, by which a lock on this principle can be opened." In Bramah's lock, the principle of tumblers or movable obstacles is applied differently to that in others, and the use of wards is entirely abandoned. In a kind of prefatory record which was attached to his specification, Bramah alludes to the insufficiency, for the purpose of security, of all contrivances of the ward, or fixed obstacle character, because, according to Holland's abstract of his argument, "the variations capable of being made in the disposition of such wheels or wards, and in the form of the key's bitt, are not sufficient to produce the required number of locks, without having large quantities exactly alike, and their keys capable of opening one another reciprocally. In consequence of which they become a very imperfect security against violation, as any ill-disposed person might, by furnishing himself with a number of old keys, be enabled to open almost all the common locks in the kingdom, with as little difficulty as if he had in his possession the key belonging to each lock." In devising a remedy for these defects, Bramah contrived a method of applying more impediments, very different to that adopted by Barron. Retaining the principle which required the withdrawal of every such impediment in its own peculiar movement, he provided for restoring them, by the application of an elastic force, in such a position as should leave no trace and afford no possible clue to the discovery of the extent of their motion under the presence of the key; so that the opening of his lock without the true key is, to use his own expression, "as difficult as it would be to determine what kind of impression had been made in any fluid, when the cause of such impression was wholly unknown; or to determine the separate magnitudes of any given number of unequal substances, without being permitted to see them; or to counterfeit the tally of a banker's cheque, without having either part in possession." To explain how the principle of security is applied in Bramah's lock, we should explain that the ordinary mode of shooting the bolts by the action of the bitt of the key is entirely abandoned in it; the office of the end of the bitt being performed by a stud attached to the end of a cylindrical barrel, which is mounted in the lock, and which contains all its essential parts, or rather, all the parts essential to its security. The portability of the key constitutes a great advantage to this kind of lock, as a key which may always be carried in the waistcoat pocket, or even attached to a watch-chain, is less likely to be mislaid, or to fall into the hands of improper persons, than a large key. Again, both locks and keys, being made almost wholly by machinery, may be made with great accuracy at a moderate cost; while the production of a false key from an impression of the true key, or even from the key itself, would be no easy task to a person not possessed of the requisite machinery. For some time after the introduction of this lock it was deemed absolutely inviolable, but ingenuity at length overcame the difficulty of picking it. This was accomplished by what has been aptly termed the *tentative* or *trying* process. Force being applied to the barrel in such a way as to give it an inclination to revolve on its axis, the picker tried all the sliders in succession, to ascertain which of them, by the inevitable inaccuracy of workmanship, pressed with most force against the circular locking-plate. This slider he then gently pushed, until, by the cessation of the resistance of its locking-plate, he found that its notch was in the required position; when, having secured it, he proceeded to adopt the same course with each of the other sliders in succession. Then, by an extraordinary exercise of patience and delicacy of hand, etc., a very skilful operator was able, in many instances, to accomplish the apparently impossible feat of picking a Bramah lock. No sooner, however, was this fact made public, than an efficient remedy was provided by a person named Russell, who was then in Bramah's establishment, by the simple device of cutting one, two, or more additional or false notches on each slide, and enlarging the inner portion of each notch on the locking-plate. The result is that it is utterly impossible for a picker to know whether he gets the true notch, or one of the false notches, on to the locking-plate; while, supposing him against all probability to find the right notch in a majority of the sliders, the fact of one only hanging on a false notch would be sufficient to prevent the barrel from turning, owing to the depth of such notch being insufficient to clear the plate. The enlargement of the notches in the locking-plate, which allows of a degree of motion far exceeding any which could arise from mere inaccuracy of workmanship, adds to the baffling effect of the false notches, by the use of which the Bramah lock may fearlessly be said to be rendered, so far as any mechanical contrivance can be, perfectly secure from picking. The same principle of picking, and the same kind of security against it, with variations of detail, which need not be noticed here, have been applied to tumbler locks of the more ordinary construction.

The infinite variety attainable in the manufacture of locks on this principle forms one of its great recommendations. In one of its simplest forms only four sliders are used; but even in this form the variety attainable without any difference in the size of the key, or the diameter of the central pin, is very great. By the use of five, six, or seven sliders, the number of different locks, each of which may have the same external appearance, but can be opened only by its own proper key, is increased almost to infinity. Bramah himself showed that if twelve sliders were employed, the number of changes which might be produced by simply varying their relative positions would amount to 479,001,500; while, by adding one more slider, the number would be increased to 6,227,019,500; so that, as he observes, "one lock, consisting of thirteen of the above-mentioned levers, sliders, or other movable parts, may (by changing their places only, without any difference of motion or size) be made to require the same immense number of keys." It may be observed that, in the event of a key becoming lost, or the owner desiring on any account to have a lock altered, it is possible to change the relative positions of the sliders, so as to render the old key useless; and also that *master-keys* may be made, if required, by constructing a suit or set of locks, alike in everything but the position of their notches, and then applying to each of them in succession the intended master-key, which must have notches different to any of the ordinary keys, and cutting new additional notches in the sliders to suit it. Such, indeed, is the principle upon which the notches of ordinary Bramah locks are cut, the key not being fitted to the lock, but made first, showing its notches cut by a machine which provides for a continual change in their order and depth. This done, each key is applied to a separate lock, with blank or uncut sliders, and the notches in the sliders are cut while they are thus held in the proper position by the key. By any other arrangement it would be almost impossible to secure the requisite accuracy.

Bramah, it may here be observed, presents us with an early example of a man of genius extensively applying machinery to manufactures. Thus, when he set about his famous lock, he constructed a series of machine tools for shaping with the required precision the barrels, keys, and other parts of the contrivance; this would have utterly failed, had not the tools been formed with the accuracy which machinery alone could give. The importance of such perfection has of late years been much more generally appreciated than in Bramah's time.

In Bramah's workshop was brought up the celebrated Henry Maudslay, who went there as a young man of eighteen. Bramah was then engaged upon his lock, and was at his wits' end for the means of simplifying its various parts. He was almost ashamed to apply for assistance to the youth of eighteen; but he did apply, and got the most valuable aid from Maudslay, who was working in Bramah's shop for little more than a pound a week.

It is not within our province to pursue Bramah's lock further than to state that it was greatly improved by the inventor's sons. It was, however, picked in 1817, when it was improved by the introduction of false notches. It was again picked in 1851. There hung in the window of Messrs. Bramah, in Piccadilly, for twenty years, a padlock, to which was appended a label with these words: "The artist who can make an instrument that will pick or open this lock shall receive 200 guineas the moment it is produced." The lock contained no less than eighteen sliders, and supposing the projecting surface of each slider to admit of only six different situations for each notch, it presented a sum of security as compared with unity of 678,651,612,807,168,000. How many lives would it take to hit by chance upon the right key out of so many changes? A long controversy ensued as to the actual compliance with the conditions of picking: the case of Messrs. Bramah was referred to a committee of arbitrators, who, having witnessed certain experiments, decided that Mr. Hobbs, the American operator, had picked the lock without injuring it, and Messrs. Bramah accordingly paid him the 200 guineas, though he had used three or four instruments instead of one, stated in the challenge. The padlock is stated by Messrs. Bramah to have been imperfect; and they produced another lock, which they challenged Mr. Hobbs to pick, for 200 guineas. The *cui bono* of the affair has been thus pertinently illustrated:—"The public, while they admire the expertness with which this mechanical feat has been performed, will not attach more importance to it than it deserves, or undervalue the merit of our best locks, because an American operator, highly accomplished in such matters, has succeeded, after an arduous struggle, in opening them. The facilities given to him were such as no thief could ever possess, even if he had the necessary ability; and it is quite clear that the operation has not been one of ordinary picking."—*Times*, September 4, 1851.

To return to the career of Joseph Bramah. From the lock he turned to the steam-engine, and made several valuable improvements in it. Stuart observes: "After a series of experiments, in which Watt had been engaged for twenty years, to develop his ideas, the splendid result of his genius and perseverance—the perfect machine—was raised up in judgment against him, to prove that between the years 1790 and 1800, the engines which were sent from Soho were more perfect than could be fabricated from the description he gave of the one he erected in the year 1760." Bramah, whose own distinguished ingenuity and personal acquaintance with the subject, joined with his high integrity and regard for truth, rendered him a dangerous adversary, was enlisted among the determined opponents of Watt's patent. This he attacked safely on the ground just stated, while his printed letter to the judge who presided at a trial on which he had appeared as a witness, is referred to by Stuart as being throughout a series of admissions of the value of Watt's contrivances, in which "he points out inventions that had escaped the notice of others, with all the fine feeling of what is beautiful in an art in which he was himself a master; while he ceases not by inference to ask if the inventor has described these in a proper manner; and he comes always to the same conclusion, that because he has not, therefore he is not entitled to any reward for his superlative invention;" although, after a series of trials extending from 1792 to 1799, a unanimous and clear decision was given, fully vindicating and establishing the rights of the patentee.

Bramah's greatest invention is the hydraulic, or, as some persons erroneously term it, the hydrostatic press, patented by the inventor in 1796. It has therefore been known to the world for seventy-five years, and is now applied in a multitude of operations, which absolutely could not be performed at all without it. The boundless power which it enables one man to exert, renders it an important agent in many manufacturing processes, one of which is the powerful hydraulic discharging press used in the manufacture of bandana handkerchiefs. Thus, in the Barrowfield Dye Works, near Glasgow, there are sixteen presses for the production of bandanas; and when these are in full work, the period required for the complete discharge of the colour in the first press is equal to that required for bringing the remaining fifteen into action, so that one discharger, with his assistants, can keep the whole in constant operation. The entire routine of operations occupies about ten minutes, so that the sixteen presses (each producing fourteen handkerchiefs at each operation) will produce 224 handkerchiefs at each time of working; the whole being completed within the short space of time mentioned above, and by the aid of powerful and ingenious machinery requiring only the labour of four men to effect the various necessary changes and adjustments.

The hydraulic press is of very great power in compressing bodies or lifting weights; or again, in drawing up trees by the roots, or piles from the beds of rivers. Its power in compressing woollen and cotton goods is well known, and reducing hay to such dimensions as to be easily packed on board transports. The press acts on the principle of the philosophic toy called the Hydrostatic Paradox. When Pascal, in 1653, was pursuing his experiments on the weight of the air, in order to determine the general condition of the equilibrium of fluids, he fixed to the upper end of a cask set upright a very long and narrow cylinder. In filling the barrel, and afterwards the cylinder, the simple addition of a pint or two of water, which the latter was capable of containing, produced the same effect as if the cask, preserving its diameter throughout, had its height increased by the whole length of the cylinder. Thus the increase of the weight of a pint or two of water was sufficient to burst the bottom of the hogshead, by the immense augmentation of the pressure it occasioned. Now, if we suppose the water removed from the cylinder of narrow dimensions, and replaced by a solid of equivalent weight, such as a piston, it is evident that the pressure must remain everywhere the same. Again, if we suppose the weight of the piston to be multiplied by the power of a lever acting on its shaft, the pressure will be proportionally augmented, so as to produce on the bottom of the cask a pressure equivalent to an enormous weight, with the exertion of very little primitive force on the piston. ("Notes in various Sciences," 1827.) The most remarkable part of this discovery, and one which of itself would have immortalised Pascal, is his application of the general principle to the construction of what he calls *the mechanical machine for multiplying forces*, an effect which he says may be produced to any extent we choose, as one man may by means of this machine raise a weight of any magnitude. This new machine is the hydraulic press of Bramah.

How inventors help each other is well shown in the share Maudslay took in producing the hydraulic press for Bramah. Maudslay at once invented the leather collar, which, on the principle of a valve, tightens under the pressure of water. "Maudslay himself told me," says Mr. Nasmyth, "or led me to believe, that it was he who invented the self-tightening collar for the hydraulic press, without which it would never have been a serviceable machine. It is the one thing needful that has made it effective in practice. If Maudslay was the inventor of the collar, that one contrivance ought to immortalise him. He used to tell me of it with great gusto, and I have no reason to doubt the correctness of his statement." It was after this invention that Maudslay left Bramah, because the latter would not raise his wages beyond thirty shillings.

It has lately been stated in the *Engineer* journal that "Presses exerting a force of 500 tons, and having ranges of 10 feet, 12 feet, or even 15 feet, and being capable of exerting the above force at any part of the stroke, are by no means uncommon. We do not stretch a single point when we say that no arrangement of screws or levers could supply us with a press of equal range, power, or speed. It is not that an arrangement of levers could not be planned quite able to exert the strain of which we speak; but such an arrangement would lack all the characteristics which are essential to a mechanical device intended to serve the purpose of manufacturers. For example, had the work done in raising the tubes of the Britannia Bridge been performed by a simple lever, one arm must have been 448,000 times longer than the other, and to enable a pound to raise the weight through 100 feet, the pound must have passed through space for a distance of 83,522 miles. In simplicity, in cheapness, and in efficiency, the hydraulic press stands totally without a rival. Whether assuming the form of the gigantic apparatus employed in bending armour-plates, or that of a little 30 cwt. jack, it is equally compact, inexpensive, and elegant."

In the Museum of the Commissioners of Patents, at South Kensington, is deposited the "First Hydraulic Press ever made.—Joseph Bramah, Letters Patent, A.D. 1795, March 31. No. 2,045."

Next among Bramah's inventions is the well-known beer-machine, of universal adoption in taverns, for drawing liquor in the bar from barrels deposited in the cellar, by means of a force-pump. He also improved machinery for producing smooth and accurate surfaces on wood or metal; in making pens by a mechanical process, by which several nibs, resembling steel pens, were cut out of one quill, and fixed in a holder for use.

In the year 1806 Bramah contrived an exceedingly ingenious mode of printing, which was shortly afterwards applied to the numbering of bank notes, and by the introduction of which, during the issue of one-pound notes by the Bank of England, the labour of 100 clerks out of 120 was dispensed with. This machine consists of a number of discs, or wheels, with the numbers from 1 to 9, and 0 cut upon the periphery of each, the whole being mounted upon one axle, but capable of turning independently of each other. By the action of mechanism, which is incapable of error, the position of one wheel of the series is moved between each operation of printing, so that when the machine is properly adjusted it will print a series of numbers in regular progression, without the possibility of twice producing the same number.—*Penny Cyclopædia Supplement.*

In 1812 Bramah patented a scheme for laying mains or large water-pipes through the principal streets of London, of sufficient strength to withstand great pressure, to be applied by force-pumps; his object being to provide the means of extinguishing fires by throwing water without the aid of a fire-engine, and also to supply a lifting power applicable to the raising of great weights, by forcing water or air into an apparatus consisting of a series of tubes, sliding into one another like the tubes of a telescope, and capable of being projected when necessary. He asserted his ability to make a series of five hundred such tubes, each five feet long, capable of sliding within each other, and of being extended in a few seconds by the pressure of air to the length of 2,500 feet, and with such an apparatus he proposed to raise wrecks and regulate the descent of weights. By the construction of some waterworks at Norwich, Bramah acted with success in the department of the civil engineer.

The active life of this ingenious man was now drawing to its close. The last patent obtained by him was for a mode of preventing dry rot in timber, by co[illegible]ing it with a thin coat of Parker's Roman cement. He may be said to have died in harness, in consequence of cold contracted while superintending the uprooting of trees in Holt Forest by his hydraulic press, on the 9th of December, 1814, in his sixty-sixth year. He was a man of amiable private character, and his energy and probity in business were alike admirable. His works in Belgrave Place, Pimlico, were described in 1817 by a home tourist as "the manufactory of the ingenious Bramah, whose locks baffle knavery, and whose condensing engines promise such important results to philosophy and the mechanic arts."

FISH CULTURE.—VII.

By Greville Fennell.

THE STORMONTFIELD BREEDING PONDS AND APPARATUS—SUITABLE FOOD FOR NEWLY-HATCHED BROODS, ETC.

We now turn to the present year's report upon the Scotch salmon fishery, and learn much in the lesson which Stormontfield has afforded of late, that may have affected failures elsewhere. We give the text entire:—

"Stormontfield is now so well known to salmon culturists, that," says Mr. Buckland, "I shall not attempt to describe details. Suffice it that boxes of wood are sunk into the ground; water is conducted from a neighbouring mill-lade, allowed to pass through a filtering pond, and then flows through the boxes; the water is then conducted into two largish ponds. Without wishing to detract from the meritorious painstaking and expense of those who have instituted and worked the hatching apparatus, I venture to remark that the whole process, as now carried out, is capable of great improvement.

"The principal faults of the Stormontfield breeding-place are—

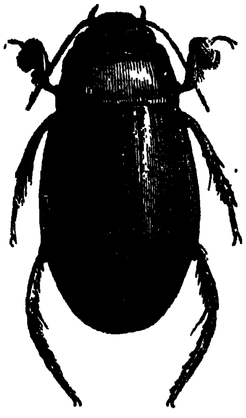


Fig. 13.—DYTISCUS MARGINALIS.

"1. That the stones in the boxes are a great deal too large, and there are too many of them in each box; the result is, that the eggs which fall down to the bottom of the box among the stones do not receive a sufficient current of water over them.

"2. Many eggs not properly impregnated in the first instance—technically called 'blind eggs'—die, become white, and are covered with a mildew like fungus, which is very detrimental to the healthy eggs, and also to the young fish when just hatched out, for it is very apt to give the fish also a fungus disease about the gills, called 'gill fever.'

"That the dead and fungus-covered eggs were still at the bottom of the boxes among the big stones long after the fish had hatched out I satisfied myself by personal examination.

"3. The little fish which hatch out properly must, I think, often have difficulty in getting out from under the big stones when their umbilical bag is absorbed, and the time arrives for them to feed. I saw several fish among the stones which were half starved. It is impossible to feed these fish when among the stones.

"The fish gradually fall back from the hatching-boxes into the ponds. This, I think, is wrong. The ponds themselves were full of dense banks of weeds, and a comparatively small space was left open for the fish, which, as is the habit of fish, had accumulated near the spot where the running water from the boxes comes in. These weeds must of necessity breed numbers of predatory water-beetles, *Dytiscus marginalis*, and to my personal knowledge there are no greater enemies to young fish than these beetles.

"The fish in these ponds must be fed artificially. I do not consider they have sufficient food, and it must be recollected that the food which escapes them falls to the bottom, and when decaying fouls the water. The remedy for this is to turn down common craw-fish to act as scavengers.

"When the migratory instinct prompts the young fish to descend to the sea in the spring months, they are enabled to leave the ponds and get into the river by means of an artificial channel out from the ponds to the river.

"I feel quite certain that a large number of smolts, hatched out with such expense and trouble, do not get down to the sea at all. The pike assemble at the mouth of the little stream down which the young smolts come, and eat a very large quantity of them, so that much time and money is expended simply for the benefit of the pike; I do not, I confess, know that this is the case from my own observation, but I feel most certain that it must be so.

"To obviate this mischief, I have strongly recommended the Tay District Board to have the river at and near the stream by means of which the smolts join the river netted regularly under proper supervision twice a day during the time that the smolts are on their downward march.

"The mesh of the net should be small, in order to catch the pike; all salmon and salmon smolts must, of course, be immediately and carefully returned to the water.

"Great praise is due to Mr. Peter Marshall for the manner in which he looks after the hatching apparatus; also to Mr. Brown, who superintends them; both these gentlemen do credit to the memory of the late Mr. Robert Buist, who was the founder of the first establishment in Scotland for rearing salmon by artificial means.

"Still I say, as is my duty, that the Stormontfield apparatus is capable of great improvement; and this—

"1. By using gravel sifted through an iron sieve with a half-inch mesh. The eggs should be placed on the top of these stones—not, as now, buried under the large stones.

"2. By covering the boxes with boards, so as to keep out the light.

"3. By netting the pike during the time the smolts are going down.

"4. By keeping the ponds clear of weeds; this will be best done by drying them entirely. Fish always do best in a pond which has been dried and re-filled with water.

"5. Best of all by sending the fish to the upper waters."

If properly managed, 80 to 85 per cent. of fish will hatch out. These require six times the space as the eggs. From the time of the absorption of the navel-bag, the opinions and proceedings of the managers differ. Some say that with this the artificial culture terminates, and placing the brood at once in the selected water, they leave them to their fate. They say feeding of the young fish in enclosed spaces has only the value of scientific experiment, but is objectionable for practice on a large scale; to make fish into domestic creatures, and to keep trout in washing tubs, is just as foolish as to keep deer in a stable. This is illogical; for why do we take the eggs but to protect them from their numerous enemies? then why not protect the tiny fry from its enemies until it can take its own part? Others consider that the little fish, before they are turned out, should be fed in enclosed places. After the loss of the navel-bag they immediately feel the want to feed, their movements become lively, and they require more water to find more air for their breathing. All sorts of nourishments have been proposed, according to the method and experiments of Coste, Jourdier, etc., and apparatus for mincing it, to feed the fish for a shorter or longer time before turning them out. Mr. Hartmann says: "I will only remark that every process by which the young fish have other than their natural, that is, living food, given them, is under every circumstance to be rejected. Clotted blood has been forced through fine squirts, in order that it should have a worm-like appearance; small minced flesh; liver or calves' brains made into a paste by kneading with the fingers; boiled meat or bullock's heart high dried and then rubbed or grated"—and, it might have been added, the white of egg, custard, boiled rice, peas-pudding, and many fancy feeds all invented with the best intentions, and if not positively mischievous, at least good for nothing. We are not here feeding the carp tribe—which would gladly receive and gratefully get fat upon such offerings—but, as Mr. Hartmann says, a class of rapacious fish that feed almost solely upon living food. A chief evil is, as we have elsewhere stated, that all the food which is not immediately devoured when thrown in sinks to the bottom, and there forms a shiny putrefying layer, which corrupts the water, and may cause the death of the brood. The frequent removal of the putrefying stuff is of little or no use, irrespective that such stinking stuff must be injurious to every fish that may chance to swallow it. These live in freedom on the small creatures—worms, insects, etc.—which keep about the aquatic plants. In confinement a suitable food can always be procured in any quantity, by throwing into the pond the well-known green water-weed, between the roots of which innumerable water creatures live. In freedom, the smaller water insects, particularly small shrimps, afterwards insect larvæ, and worms, form their chief nutriment. The fine specimens of grayling trout and salmon trout, shown with pride at Huningue as the result of artificial culture, do not contradict our opinion, because it is not known, or is kept secret, from how many thousand hatched fish the few shown specimens remain alive. Mr. Buckland considers that with all the numbers of ova which have been sent to Tasmania by himself and Mr. Francis Francis, if two or three remain alive as adult salmon it is a fair result. They are certainly right who consider the feeding in enclosed spaces only as a scientific experiment, but to be rejected for practice; but there is a great difference between sending creatures at once amongst their natural enemies who are waiting for them at every outlet into the main stream, and keeping them shut up in comparative bondage. A mean between the two would occur to most sensible people—plenty of room, natural food, and protection from jack, perch, and other devourers of so tender and delicious a morsel as a young salmon. But then we are met by Molin, who says, "It only requires any one to attempt to provide the proper quantity of living food when there are 30,000 or 40,000 fish to be fed, to be convinced that this is not practicable on a large scale. To those who doubt it I will say, that Coste saw four trout, each 25 millimetres long, in less than five days devour about 30,000 perch embryo." "The immense destruction which young Rhine salmon and trout can commit among the needle-like transparent brood of perch and white fish, which shoot about their ponds," says Hartmann, "I have repeatedly seen myself; but it is just these attempts at feeding which have convinced me that, without too much cost of time and labour, the natural food could be obtained for many thousands of young fish: of course this is assuming some knowledge of the lower insect world inhabiting the water. If we closely examine the water at all seasons, even in winter under the hard frozen ice covering of a lake, pool, etc., we find, even with the naked eye, an active life of all sorts of little creatures swimming about, giving quite a greenish, brownish, or reddish colouring to it." It is therefore clear that Mr. Hartmann considers there exist other more rational courses than at once to turn the young trout into deep waters to fight the battle of life so overmatched by their enemies, by whom the stream is certain to be occupied. In the food of the trout, to which allusion has been made, the naturalist will find members of the classes crustacea, brachiopoda, and entropostraca. Of the brachiopoda he finds the water-flea (*Cladocera*), with the species sida and daphnis; and ostracodea, with the species cypris; the copepoda, with the species cyclops. The largest of them are somewhat more than a line long, but the smallest are hardly visible to the naked eye. The majority have only one large eye in the middle of the head, and two pair of strong feeler horns, which specially serve for their active movements. Many have bushy tails, others are tailless; with some are seen eggs lying in considerable numbers inside behind the transparent shell of the body; others carry their eggs outside in a small bag fastened to the tail; in others—the minority—there are no eggs, these are the males. The young have a different form of body from the old ones. The development and propagation of these creatures is very remarkable, and accounts for their being increased in such wonderful quantity and found everywhere. From the earliest spring only female water-fleas are seen, and these lay eggs through the whole summer, which produce fresh broods without being impregnated. This process continues with the young, which soon attain the form and size of the mother; the same process is repeated, and hence it happens that the number of the posterity of a single water-flea in the course of a warm season is so enormous as to be quite bewildering. The males appear first towards the autumn, and now the females, after preceding impregnation, lay the so-called winter eggs, which are enclosed two by two in small parcels in a tough protecting case, in which they remain, in spite of the water drying up, and frost, through the winter. These lower creatures, then, forming the first food for the fish brood, can any one say that their larder is not amply stored, provided we find the proper water and aquatic plants for insect generation and increase? and, this admitted, is there any other excuse worth refutation for the practice of turning the fry out at once into the open deep?

We are told that Professor Jager was summoned several years ago from Vienna to the fish-culture establishment of Baron Rothschild at Silesia. The manager had informed him that out of 20,000 trout hatched, shortly after beginning to feed them with brains and blood, they all became suddenly sick, except about 200. They had become indolent, had a pallid appearance, and, in spite of the greatest care, the death of the whole brood was to be feared. After his arrival (it was in March, a covering of ice lay partly on the waters) Jager at once perceived what was wrong. He went to a ditch, and obtained, by means of a fine muslin hand-net, a large quantity of these water creatures, and threw them into the pond of the sick fish. On his return he said to Mr. Hartmann, with joy, like a doctor that has successfully performed a difficult cure, "You should have seen what a change took place in the fish at once! They swam about briskly, and snapped continually at the water-fleas, which were before their noses; only a few had already become so weak, that they could not take part in the chase with their comrades, and therefore died. But the others visibly recovered from minute to minute, their bellies were full and round, the sickly thickness of head disappeared, the pallid bodies regained the dark healthy colour, and when the next day the feeding cure was repeated, with the exception of a few deaths, the whole were cured." Fourteen days after, during which the brood was properly fed, they could be turned out with safety. The above is not alone of great importance to the fish hatcher, but to all owners of valuable trout fisheries. If the natural food of the fish is scarce—perhaps rendered so by a too great fastidiousness in the removal of weeds—the fish will get lank, bull-headed, and sluggish. Indeed, in one portion of the Wandle, the trout—which are too plentiful even were the stream full of insect food—for the want of a due supply of the latter, were, in August, 1871, as black as they would be in February, instead of being plump, fat, brilliant, and active as they ought to be.

Hartmann, commenting upon this anecdote, says it was not so much a matter of scientific experiment as that of the practice of fish culture on a large scale. And then he goes on with very many valuable facts in corroboration of his views. He maintains it is not desirable to turn out the brood immediately after the loss of the navel-bag. During the whole of the navel-bag period, which, with these noble fish, lasts as long as the embryo time (four to six weeks), the little fish lie together in thick masses, generally motionless, on the dark bottom of their breeding place, only fanning quickly with the large breast-fins, for the purpose of renewing the water necessary for their respiration. At this time they take no food at all, as they obtain it from the navel-bag itself, because this is in connection with the intestines, into which it is gradually absorbed and digested. Then the little creatures become lively, seek the light, and the places where the water is most in motion. They do the same in the stream or river; but woe to the weak which get into the strong current! many are carried away. In most years the thaw of the snow occurs just after the turning out, and then, when the brooks and streams are swollen, the fish suffer most. Many meet their death while, left to themselves, they learn to seek their food. This is the chief reason which is against turning them out immediately after the absorption of the navel-bag, and why they should be fed during their earliest youth in enclosed places until they are strong. After the disappearance of the navel-bag their requirements are different than in the previous period of development. They now require for their growth and thriving not only food, but direct daylight and water warmed by the rays of the sun; while on the previous period of development, darkness, and cold water are important essentials. For the feeding of the brood ponds should be used which may be easily, quickly, and thoroughly superintended and kept in order. Three conditions are necessary: there must be ample space for the movements of the brood, there must be sunny and shady places, the water must circulate in them, so that an equal distribution of the food may be effected, and a crowding of the fish in particular places prevented. "In my opinion," says Mr. Hartmann, "I think the arrangement of the feeding-places should be as follows:—At a spot shaded by trees, not too far from the breeding-house, a number of basins should be laid down, which are supplied from one source. Some points must be observed in the arrangement. The water-channels which bring the different basins into communication must be so placed that the water runs through the whole equally from the first to the last. I would have oblong-shaped basins, each with a surface of about six square feet, and one foot deep; in each the water must be between six and nine inches deep. This shape has the advantage over others, because the water can be made to revolve, and the food be equally distributed. A basin of the above size can receive 5,000 fish. The feeding of the young fish should continue, at least for six or eight weeks from the time they begin to eat, from about the middle or end of February, to the middle of April."

During the first fourteen days the small water creatures above mentioned must be the sole food of the brood, and the manager must give his chief attention to procuring the sufficient quantity, as the final success depends on the fish getting over the first few weeks in a healthy condition. No one who undertakes fish culture seriously should permit himself to be deterred by the diminutiveness of the creatures mentioned, of the innumerable quantity of which in all standing waters he probably has hitherto had no conception, or by the preconceived idea they cannot be obtained in sufficient quantity. Mr. Hartmann suggests that he should make the trial with a smaller number, about 10,000 young trout, and have two or three feeding basins made. The most simple mode of collecting the food is by stretching a square piece of linen on four laths at the edge of the water, and then continually pour water from the pool with a ladle. The little animals will be retained on the cloth, and by a boy or girl continuing this work for one or two hours, a daily provision for 10,000 small trout may be obtained. After fourteen days, the end of February, or beginning of March, he may use coarser food, for which two sorts of insect larvæ, one found in running, the other in stagnant, water, and a sort of water-worm. At the commencement of spring there is found everywhere in brooks and rivulets, on the blades of grass hanging in the water and driving about the water, the larvæ of the *Simulia*. Frequently a stalk is quite covered with them, to which they are attached with a fine thread. With some practice, in an hour or two as many of these plants covered with larvæ may be collected as will serve to feed 10,000 trout. These larvæ become afterwards the midges which annoy men and cattle.

SHIP-BUILDING.—X.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF WOOD AND COMPOSITE SHIPS.

Having briefly sketched the principal features of the framing of ships, we now propose to notice the chief methods of arranging their skins, which are perhaps the most important parts of the structures. Vessels have been built without framing, but every vessel, however constructed, must obviously have a water-tight skin in order that she may keep afloat. As both wood and composite ships have their skins formed by assemblages of wood planking, it will be convenient to take these two classes first, and afterwards to notice the skins of iron ships.

The planking on the outside of the frames of wood ships is usually worked in one thickness, and formed of strakes varying from, say, 8 to 12 or 14 inches in breadth; the length of the individual planks usually lying between 18 or 20 and 24 feet. The ordinary practice, it need scarcely be said, is to place the planks with their length longitudinally, so as to cross the frames at right angles. Two considerations necessarily have to be borne in mind by the ship-builder in forming the skin efficiently, viz., (1) the *arrangement* or *disposition* of the planks, and (2) their *fastenings*. We will glance at each separately, and in this we shall be aided by the sketch in Fig. 27, which shows an outside view of a portion of the planking of a wood ship.

In arranging the planking it is usual to employ either a model of the vessel, or an "expansion drawing" of the outside, and upon it to draw the lines representing the edges of the various strakes of planking. These lines would be so placed as to admit of the breadths of plank required being readily obtained, and also to allow the planks to be wrought upon the framing with the least amount of difficulty. Next comes the very important step of placing, or "shifting" the butts of the planks, in doing which great care is required. It has already been pointed out that plain butts, such as are shown by B, B, in Fig. 27, although well calculated to transmit compressive strains along the strakes where they occur, are not at all efficient against tensile strains, and consequently it is most important to get as many passing or unbroken strakes as possible between consecutive butts lying on the same transverse section. Turning to Fig. 27, it will be observed that the butts (B) are placed upon frame-timbers, and that there are no less than three passing strakes between consecutive butts. This disposition is always made in the Government service, and generally adopted in merchant ships. It is noteworthy too that if the eye is carried from the butt of one strake to the nearest butt of the strake next below it, and so on, it is impossible to pass from butt to butt by a series of "steps" of equal length and ranging in the same direction. This fact is important, because wood shipbuilders universally disapprove of shifts of butts where "steps" occur. In the Government service the minimum distance between the nearest butts in adjacent strakes is usually six feet; in merchant ships this distance is often not more than five feet.

The outside planking of wood ships is not usually of uniform thickness from the garboards to the topsides. The thickest planking, termed "the wales," is generally placed near the main-breadth of the vessel, and in the neighbourhood of the load-line to which she floats when fully equipped. For some distance below the wales, in the Government service, it is usual to have what is called "diminishing stuff," an assemblage of planking of which the thickness is gradually diminished, until it equals that of the "bottom planking" proper, which extends between the garboards and the diminishing stuff. In merchant ships the bottom planking is generally of uniform thickness from the wales downwards; and from the wales upwards it is also uniformly thick, being generally a little thicker than the bottom planking, but not so thick as the wales. The names given to the planking above the wales in merchant ships are "sheer-strakes" and "topside planking." In wood ships of war having one or more tiers of guns, there are necessarily special assemblages of planking above the wales, bearing special names, such as "channel-wales," "sheer-strakes," etc., besides the short planks fitted between the portholes where the guns are fought; but respecting these it is not necessary to say more here.

Although Fig. 27 illustrates a common arrangement of the skin, in which planks are "fair-edged," it does not represent the only method adopted. With wood as the material employed, the builder has to consider its economical "conversion" as well as its good combination, and in providing thick oak planks for the wales he sometimes finds it advantageous to adopt one of the plans represented in Figs. 28, 29. The first of these, "top-and-butt," is more commonly used, and is especially suited to English oak planks, which, from the form of the tree, can be best provided wider at one end than at the other. It will be remarked that the broadest part of each plank is situated at one-fourth of the length from one end, and that the breadth at the butts is only about two-thirds the maximum breadth. The planks of two adjacent strakes are so fitted to one another, that their outer edges are parallel, and there is obviously no difficulty whatever in carrying out the shift of butts illustrated in Fig. 27. Greater care is required in fashioning planks worked top-and-butt, than is needed on the ordinary plan; but this is probably more than compensated for by the saving in conversion, especially with very thick plank.

The other plan illustrated in Fig. 29 is not nearly so economical in conversion as top-and-butt, nor is it so common. Its use may, in fact, be said to be almost confined to assemblages of planking where there are but few strakes, and where a good longitudinal tie is required. For example, in some line-of-battle ships the "channel-wales" (a term requiring no explanation) and sheer-strakes have been planked on the "anchor-stock" plan; and it has been used too for some parts of the inside planking. Two strakes make up a parallel strip, as in top-and-butt, only the greatest breadths of the individual planks are here placed at the middle of their length; the butts are each about two-thirds of the maximum breadth at the middle of each plank. The symmetrical form thus produced has given the name of "anchor-stock" to the arrangement.

So far attention has been confined to the outside planking, and but little need be said respecting that worked inside the frames. The latter does not always form a complete skin like the former, but it is nevertheless of considerable importance from a structural point of view. Between the decks it is usual to work thick planking, named "clamps," "spirketting," etc.; several strakes of clamps are also usually worked in the hold directly beneath the lower deck. The remainder of the inside planking in the hold is generally made up of separate assemblages of thick "binding strakes," with the spaces between them covered by thinner planking termed "ceiling." In different vessels different plans of arranging the binding strakes are adopted. One of the most common is to have two or three thick "limber-strakes" on each side at a short distance from the keelson; and to associate these with three or four strakes of plank worked over the floor-heads, or the first-futtock heads, or over both if the vessel be of large size. In the Government service it has been customary to fit, at intervals, strong diagonal planks, named "trusses," between the lowest strake of the clamp, and the uppermost of the binding strakes upon the first-futtock head. These wood trusses have been placed at right angles to the iron plate-riders worked upon the frames, and when a second set of riders were used they were made to lie along upon the wood trusses, which thus gave them a fair bearing in the spaces intervening between the lower-deck clamps and the binding-strakes. Merchant vessels are not usually built with trusses, but the spaces between the limber-strakes, binding-strakes, and clamps are covered with thin ceiling worked longitudinally. In some cases the ceiling is placed diagonally to give greater strength. Thin ceiling is used also in the Government service, but fitted rather for protection to the timbers than for any other purpose.

In order to make the internal planking strengthen the structure as much as possible, care must be taken in shifting its butts, having respect not only to the particular assemblages of which it consists, but also to the butts of the outside planking. To strengthen the ties formed by the binding-strakes, etc., it is not uncommon to dowel them to the frames, and this connection obviously makes them more efficient against tensile strains. The contrast between such modes of giving longitudinal strength and that previously described when dealing with the framing of iron ships cannot, however, be overlooked; and in some of the modern ships of the navy iron hold-stringers (formed of plates and angle-irons) have been substituted for wood binding-strakes, in order to gain equal strength with a less cumbrous and weighty combination.

Attention will next be directed to the *fastenings* of the skin-planking of wood ships. These usually consist of through-bolts and tree-nails driven through the planking and timbers, and also through the inside planking in wake of them. Iron and copper are the materials generally used for bolts, the iron being sometimes "galvanised" or coated with zinc to preserve it from rust. Many merchant ships have only iron bolts; but copper bolts are to be preferred for at least the under-water portions, especially when the ship's bottom is sheathed with copper or mixed metal, as there is then no chance of galvanic action being set up, such as is almost certain to occur if iron bolts are used, and to lead to the rapid wasting of the bolts. The tree-nails are long circular wooden pegs, usually formed of oak or some hard wood, and driven as tightly as possible; when in place, the inner and outer ends are caulked in order to increase their holding power. The ends of the bolts are usually "clenched" upon rings which are let into the planking, so that they may have a good hold.

Various methods of combining bolts and tree-nails as fastenings to the planking have been and still are used. It would be tedious to go over these in detail, and instead of doing so three of the principal plans have been illustrated in Fig. 27. "Single fastening," which Lloyd's rules permit for planks 8 inches in width and under, consists in having either a bolt or tree-nail in each timber, adjacent fastenings coming on opposite edges of the plank. "Double fastening," used for planks exceeding 11 inches in width, consists in having two bolts or tree-nails in each timber. "Single and double fastening" is an intermediate arrangement, and is used for planks from 8 to 11 inches in width. In each mode of fastening it will be remarked that the butts of the planks are secured by two bolts, one driven through the timber upon which the butt comes—or, as it is termed, the "butt-timber"—and the other driven through the adjacent timber. In some merchant ships only one of these bolts is driven through, the second being merely driven *into* the timber. On referring again to Fig. 27 it will be observed that while tree-nails form the bulk of the fastenings away from the butts, bolts are indicated at intervals of 5 or 6 feet in each of the methods of fastening. This is the usual arrangement in the Government service, but is not commonly adopted in the merchant service. In fact, Lloyd's rules only insist upon the butt-bolts, and leave the remainder of the fastenings to the discretion of the builder, offering him a longer term of classification as an inducement to use copper or mixed metal bolts instead of iron bolts, and to do away with a great part of the tree-nail fastenings in favour of copper bolts.

Much discussion has taken place respecting the relative merits of bolt and *tree-nail fastening*, and opinion is still divided on the subject. Tree-nails have the advantage of cheapness and lightness, and also appear to be less likely to force their way into the planking when the vessel is straining. The latter point has already been touched upon in an earlier paper, where it was shown that bolts being so much harder than wood must make it yield in wake of them when the structure is subjected to tensile strains; but the tree-nails are not nearly so hard as the bolts, and are besides of greater diameter, so that the wood in wake of them would not be so likely to yield. Bolts, on the other hand, are considered to have greater holding power than tree-nails; to be more capable of resisting the strains produced by caulking the seams of the planking, during which operation tree-nails are sometimes broken off; to wound the frames less by the holes required for their passage; and to be less productive of decay in the timbers. Some builders have been so impressed with the advantages of bolt-fastening as to discontinue the use of tree-nails, substituting for them short dumps or nails driven into the timbers. This course has not been generally followed, however, and tree-nails continue to be much used.

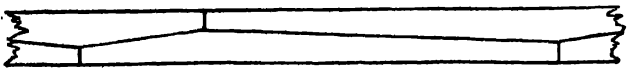


Fig. 28.—TOP AND BUTT.

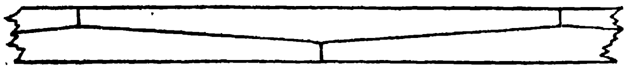


Fig. 29.—ANCHOR STOCK.

Fig. 30.

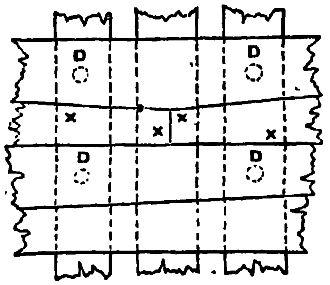
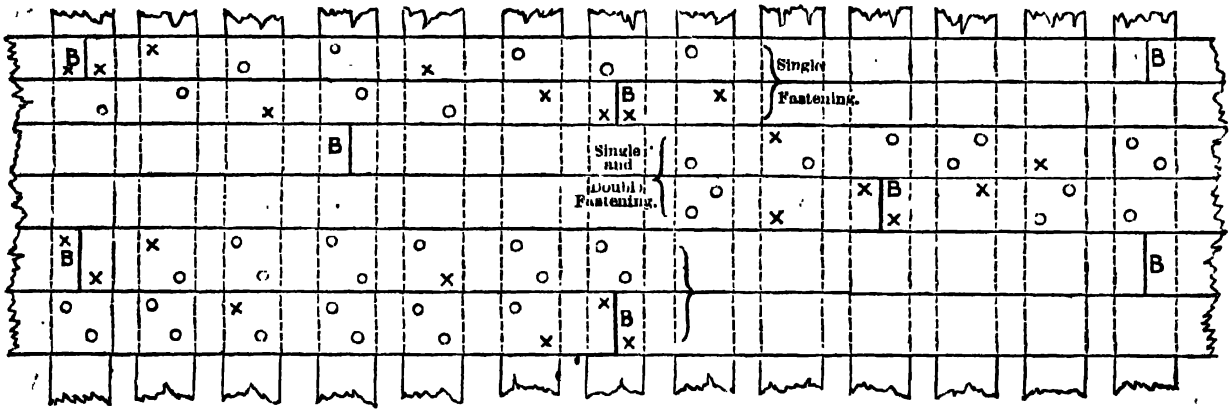


Fig. 27.



o Tree-nail. × Bolt.

In building a wood ship the outside planking is worked before the inside, and in the Government service it is temporarily secured to the frames by fastenings, known as "Blake's screws," which are driven in holes that afterwards receive some of the through-fastenings. In the merchant service it is common to temporarily secure the planking by means of a few bolts and tree-nails instead of using Blake's screws. These screws consist of bolts with an eye formed on one end and a wood-screw cut on the other, and they are found exceedingly useful in wood ship-building. Having thus temporarily secured the planking, the [illegible] of the fastenings are left undriven until such advance has been made with the work on the inside—in connection with fixing the deck beams, shelf-pieces, waterways, hooks, inside planking, etc. etc.—as enables the builder to see what additional fastenings are required. Many through-bolts are required to secure beam-knees, riders, and the various internal strengthenings, and these are so driven as to make good fastening in the outer planking also. Afterwards, when the work of "squaring off" the bottom is undertaken, other fastenings needed to complete the security of the planking are put in. It will not be forgotten that the inside planking is mainly secured by the bolts and tree-nails securing the outside planking; where additional fastenings are seen to be required, short dumps are generally employed.

The butts of the planking are confessedly weak places, the evil of which is diminished greatly by shifting them carefully, but not removed. Builders are fully alive to this fact; and, in the Government service especially, attempts have been made to strengthen the skin in wake of the butts at parts where it was considered of the greatest importance to prevent working. An example of an arrangement commonly followed in fitting the wales and thickest planking of wood ships-of-war is given in Fig. 30. In the passing-strakes next above and below the butted-strake, and in the timbers on either side of that on which the butt is placed, four dowels (D, D) are fitted, in addition to the *through-fastenings*. The aid thus given to the butted-strake is of course indirect, but not the less valuable, especially when it is remarked that at this part of a ship working is most likely to take place by means of a change in the relative positions of adjacent planks, such as was previously referred to, as "sliding of edge on edge." The top-and-butt and the anchor-stock dispositions, in Figs. 28, 29, obviously oppose such a tendency to sliding rather more strongly than the fair-edge disposition shown in Fig. 27; but in both cases the combination of planks requires to be aided by diagonal riders. Of direct edge-fastening there is none, or next to none, in the planking of most wood ships. In some cases, it is true, edge-bolts are driven in wake of the openings between the frames and through several strakes of planking; this is a good practice, but, unfortunately, it cannot be extensively carried out, as the curvature of the ship's bottom is very considerable at many parts. The caulking in the seams supplies, by its friction on the edges of the planks, a considerable amount of resistance to sliding when the oakum is first driven; but it is certain to become slack after a short time, and then working is to be most feared. This opinion is fully borne out by experience, and few will now dispute the necessity for giving a wood ship strong diagonal riders, in order to prevent working in the skin.

THE LATHE.—VII.

By Henry Northcott.

TRAVERSE SCREW—STAR-WHEEL AND DRIVER—ARRANGEMENT FOR PERIODIC MOTION OF TRAVERSE SCREW BY EXCENTRIC ON SPINDLE.

With the automatic arrangement illustrated at Fig. 22, the working of the lathe was rendered very much less tedious, and the work produced was also of a somewhat better quality, owing to the greater regularity in the motion of the cutting tool. In turning the winch-handle, and traversing the tool by hand, it is difficult to bear always in mind that the motion of the handle must depend upon the number of rotations of the work, and not upon the time in which these rotations are made. That is to say, a small article must be rotated much more rapidly whilst being turned than an article of large diameter; and the point of the tool should move the same distance during a single rotation, whether the article be small or large, quite irrespective of the time in which the rotation is effected. In turning round the handle, therefore, the screw must be moved a certain portion of a rotation for every rotation of the work itself, and if this is not done, the surface produced upon the work by the tool is not regularly lined, as would be the case if the traverse screw had a uniform motion. The larger the diameter of the work the greater is the difficulty of producing a regular traverse by hand, and the more tedious does the work become. The difficulty can be overcome to some extent by marking a line upon the surface of the article, in a direction parallel to its axis, and by carefully moving the screw-handle a certain distance each time this line arrives at a given point in its circle of rotation. But this renders the working of the lathe still more tiresome, although the work produced is of a better quality.

By connecting the traverse screw with the lathe-spindle, both the difficulty of getting a uniform traverse and the tedious nature of the operation are obviated, as the movements are quite automatic and synchronous.

In the arrangement last illustrated, the traverse screw is continually moving so long as the work is rotating, and the point of the tool cuts a continuous spiral line upon the work. This is as it should be; but in turning the screw round by hand, the tool is generally caused to cut as it were a ring at a time. The work produced is as good in the one case as in the other; but the continuous traverse of the tool is more mechanical than, and is to be preferred to, an intermittent motion. Generally, however, it is easier to obtain the periodic motion, than it is to connect the screw to the lathe-spindle in such a manner as to produce the continuous rotation of the former, and hence it is that in hand-lathes to which slide-rests are attached the traverse motion takes place after the completion of each cut.

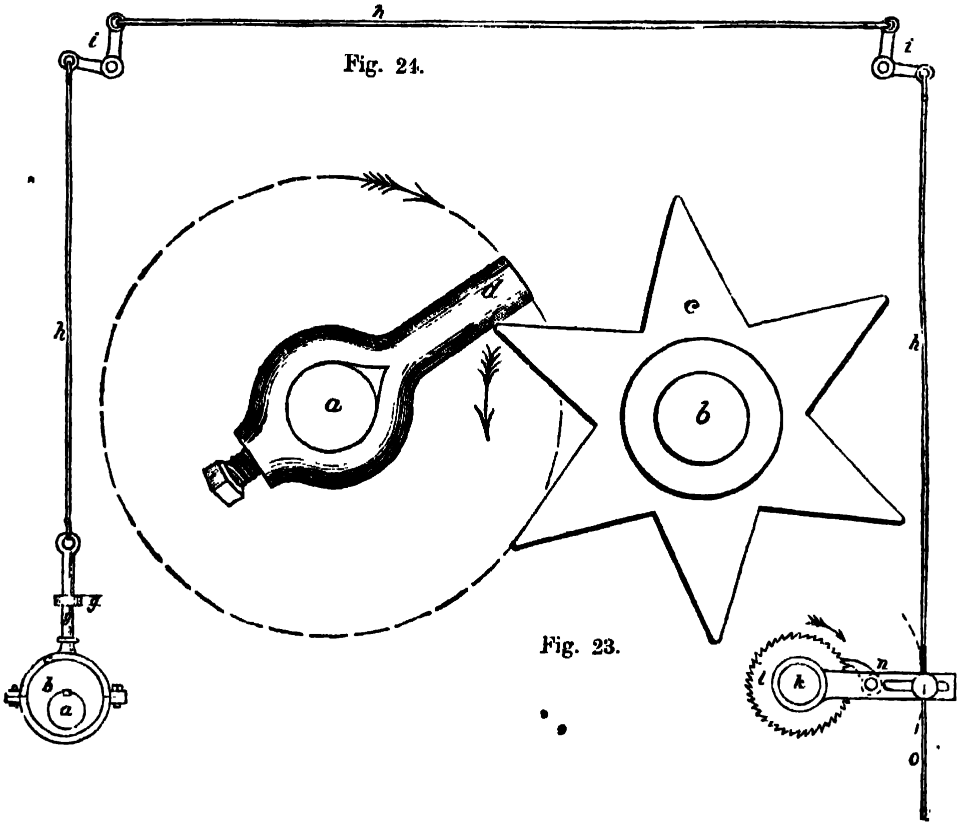


Fig. 24.

Fig. 23.

One means of obtaining the feed motion is that illustrated by Fig. 23, in which a wheel shaped like a star is placed upon the end of the screw of the slide-rest, and an ordinary lathe-carrier or driver is placed upon the article between the lathe-centres, in the same vertical plane as the star-wheel. It follows from this arrangement that on the lathe being put in motion the tail of the driver in rotating comes into contact with one of the projecting arms of the star-wheel upon the traverse screw. This arm is accordingly forced onward, and the screw is moved around also, as it partakes of the motion of the star-wheel. The driver continues its course unimpeded until it comes in contact with the next arm of the star-wheel, which it also pushes forward out of its course, and the screw of the rest is again moved slightly round. This action continues so long as the lathe is in motion, and the cutting tool may thus be caused to traverse along the full length of the slide. In the figure, *a* is the article between the lathe-centres; *b* is the traverse screw of the slide-rest; *c* is the star-wheel with any number of teeth; and *d* is the tail of the carrier, fastened upon the work, and rotating with it.

The extent of traverse will depend upon many conditions, and it does not admit of much adaptation to varying circumstances. Supposing the star-wheel to have six arms, and the driver to strike once for each of its rotations, the traverse screw will evidently make one complete turn whilst the lathe makes six. By placing on the work a carrier having two equal stems or shanks, then as they will both strike the arms of the star-wheel once during each rotation of the lathe, the star-wheel will make its complete turn during three of the work, and the speed of the tool's traverse, or distance between the cuts, will consequently be double of what it would be in the previous instance. The actual distance the tool is moved by one-sixth, or one-third of a rotation of the traverse screw, depends altogether upon the pitch or fineness of the screw's own spiral, as will be fully explained hereafter.

In arranging the star-wheel and driver for use, it is necessary, as already stated, that both shall rotate in the same plane, and also that the tail of the carrier shall be within striking distance of the star-wheel, so that the carrier cannot, in any position of the star-wheel, rotate without coming into contact with one of its arms.

The best automatic mechanism for hand-lathes is probably one of those in which the periodic movement of the traverse screw is obtained through the means of an excentric on the lathe-spindle. In the last arrangement, one of the essential parts of the mechanism was placed upon the work itself, and occupied a portion of its length. This is always more or less inconvenient, and in many cases causes the star-wheel and carrier method of obtaining self-acting movements to be quite inapplicable, either from the tool having to work upon that part of the article on which the carrier would have to be placed, or from the article to be turned being of a shape which will not allow of a carrier being placed upon it. In any case the arrangement as it stands could only be used to give motion to the tool when the latter was travelling in a direction about parallel to the line of lathe-centres. But by deriving the motion in the first place, not from any part of the work itself, but from the lathe-spindle, it can be obtained under any circumstances, and regardless of the shape of the article between the centres, which is a very great advantage.

Fig. 24 shows an overhead arrangement of this kind, in which an excentric is placed upon the lathe-spindle, generally at the left hand of the cone-pulley and gear-pinion. The motion derived from this excentric is conveyed by a cord over pulleys placed overhead, or through levers, which may or may not increase the extent of motion given by the excentric, and is then caused to actuate a lever placed upon the slide-rest screw, and move the latter round by means of a ratchet-wheel and catch. In the illustration, *a* is the lathe-spindle; *b*, the excentric placed upon it; *c*, the excentric-band or hoop encircling the excentric; *f* is a rod projecting from the excentric-band and passing through a hole larger than itself in the guide, *g*; *h* is the wire or cord fastened to the end of the excentric-rod, and passing over pulleys or through bell-cranked levers, *i*, *i*, fixed against the ceiling or the wall overhead; *k* is the slide-rest screw; *l* is the ratchet-wheel placed upon the screw and revolving with it; *m* is the ratchet-lever, which oscillates upon the slide-rest screw, and which carries a click or paul, *n*; *o* is a cord leading down to a spring or weight below.

The action of the arrangement is tolerably evident from the figure. The lathe in rotating carries the excentric around with it, and gives a reciprocating motion to the excentric-rod, and this motion is conveyed through the cords to the ratchet-lever. A downward movement of the excentric-rod causes an upward movement of the lever, and an upward movement of the lever causes a partial rotation of the ratchet-wheel and the traverse screw. The lever is brought down again by the spring or weight placed below it for that purpose. A weight is generally used, as its action is not dependent upon the position of the slide-rest, but for fast speeds the momentum of the weight consequent upon the sudden motion renders its action very imperfect. If a spring be used it requires to be attached at its lower end to some fixed part of the lathe-bed, and this is sometimes not possible, and frequently is not convenient. This method of rendering the slide-rest self-acting is infinitely to be preferred to the previous ones. The motion, it is true, is still intermittent, or periodic, but it is obtained in a very convenient manner for application. It can be communicated to the traverse screw, however the lathe may be placed, as regards angle and distance, relative to the work, and the extent of motion at each movement, or the thickness of the cut, can be regulated easily within any limits required in practice by altering the distance of the point where the cord is fastened to the ratchet-lever from the fulcrum of the lever. The further that point is from the centre or fulcrum, the less will be the motion of the ratchet-wheel and screw. If the teeth of the ratchet-wheel be tolerably fine, the thickness of the cut taken by the tool can be regulated to great nicety in this manner. The lever is generally made with a long slot or groove cut through it from near its centre to near its extremity, and the connection between the cord and the lever is made by means of a sliding screw, so that it may be only necessary to loosen that screw and slide it along the slot to the required distance from the centre to obtain any new adjustment of traverse. The mechanism is none of it in the way when not in use, and the whole of that fastened upon the traverse screw is made so that it can be removed in a piece, and replaced readily when its services are again in request.

There is another modification of the excentric motion for obtaining a self-acting traverse, in which the motion of the excentric is not taken overhead and brought down to the lever, but is communicated to a small shaft placed along the front of the lathe-bed, and from this shaft it is taken off for moving the ratchet. In this the excentric gives a rocking motion to the shaft through a lever and connecting-rod, and by the same means the rocking motion of the shaft is communicated to the lever. This latter lever, however, is made so that it can be moved anywhere along the rocking-shaft, and placed just under the ratchet-lever whenever the slide-rest may be placed upon the lathe-bed. The rocking-shaft may be neater than the overhead cord and levers, but it is not quite so convenient.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXV.—ARCHIMEDES, THE GEOMETRICIAN.

BY JAMES GRANT.

THIS famous philosopher, who invented a machine of glass which faithfully represented the motion of all the heavenly bodies, who constructed the great ship of Hiero, and conducted the defence of his native city against the Romans, was born at Syracuse, in Sicily, where his memory is still venerated, somewhere about the year 287 B.C. That he was a man of humble or obscure birth, which Cicero would seem to indicate, by the sentence, "Ex eadem urbe *humilem homuncionem* a pulvere et radio excitabo, qui multis annis post fuit, Archimedem," is not the fact, as he was a near relative as well as the friend of Hiero II., who was descended from the family of Gelon, who formerly reigned in Syracuse, and who, after being appointed captain-general by the Syracusans, was soon after elected their king. Under the tyrant Dionysius, the city had then risen to great power and splendour, and was able to maintain a force consisting of 10,000 cavalry, 100,000 infantry, and 400 galleys for war.

The mathematical genius of Archimedes set him with such excellence in the view of the old classic world in which he lived, that he became the honour of his age, and was deemed "the prince of mathematicians," being to the ancients what Sir Isaac Newton is to the moderns. So deeply did he think, that at times he became lost in a kind of reverie, during which it is said he would study for days and nights without food. He was equally skilled in all the sciences—astronomy, geometry, mechanics, hydrostatics, optics, etc.—and made many great inventions.

Among these is the pumping screw which still bears his name; a machine for launching and for raising ships in the air; and the celebrated burning glasses, which were deemed fabulous by the moderns, till Buffon made the experiment by four hundred small mirrors so disposed that when the rays from them all fell on a certain point, he melted lead at 120 feet, and set fire to a haystack at a much greater distance. Many of the treatises written by Archimedes are still extant, especially those "De sphæræ, etc., cylindro, circuli dimensio, de lineis spiralibus, de quadratura paraboles, de numero arenæ," etc., the best edition of which is that of David Rivaltius, fol., Paris, 1615.

It is related that once when King Hiero was examining with admiration some of the mechanical contrivances of Archimedes, the latter said, "Give me but a place to fix a sufficient machine upon, and I will undertake to move the earth itself!"

By a method which, however curious, is well known to every modern hydrostatic, he detected the deceit which had been practised by a workman whom King Hiero had employed to make him a crown of gold. As it was to be an offering to the gods, Hiero wished it to be one of great value and purity, and for this end weighed out the precious metal to the artificer. After some time the latter brought the crown home, and it was found to be of full weight; but it was ere long discovered or suspected that a part of the gold had been appropriated, and silver substituted in its place. Indignant at the imposition, Hiero desired Archimedes to take into his consideration the means by which such a fraud could be with certainty discovered. While engaged in the solution of this matter, he happened to go into the bath, where, observing that a quantity of water overflowed equal to the bulk of his body, it presently occurred to him that the king's question might be answered by a similar method; and hurrying to him, "I have found it!" said Archimedes; "I have found it!"

He then made two masses each of the same weight as the crown, one of gold and the other of silver; this being done, he filled a vessel with water to the brim, and put the silver mass into it, upon which a quantity of water overflowed equal to the bulk of the mass; then taking the mass of silver out, he filled up the vessel again, measuring exactly the water which he put in; this showed him what measure of water answered to a certain quantity of silver. He then tried the gold in the same manner, and found that it caused a less quantity of water to overflow, the gold being less in bulk than the silver, though of the same weight. He then filled the vessel a third time, and putting in the crown itself, he found that it caused more water to overflow than the golden mass of the same weight, but less than the silver one; so that, finding its bulk between the two masses of gold and silver, and that in certain known proportions, he was able to compute the real quantities of gold and silver in the crown, and thus manifestly discovered the fraud.

To illustrate to Hiero the effects and power of motion, he selected one of the greatest galleys in the port of Syracuse, and had it beached, with labour and by the hands of many men. He then ordered its usual lading to be put on board, and also as many soldiers as it would hold. Then placing himself at some distance, and sitting at his ease, without trouble or in the least exerting his strength, by simply turning with his hand the end of a machine which had been provided with ropes and pulleys, "he drew the galley along the dry land with as much ease and as upright as if it swam on the water."

Hiero, his friend and kinsman, was so astonished by this contrivance, and the power it depicted, that he solicited Archimedes to construct battering engines and other machines for sieges and attacks, and for the defence of walled cities. Hiero, who was great and magnificent in all his ideas, especially in the erection of temples, arsenals, and palaces, had a galley built by Archimedes; the construction of it lasted a whole year, and the king passed entire days among the workmen to animate them by his presence. The barest description of this great ship would be far beyond our limits. Suffice it that she had three masts, was coppered, and furnished with twenty benches of oars. Inside were three galleries, one for the soldiers alone. The poop was the kitchen, the floors of the apartment being laid with mosaics, depicting scenes from the "Iliad" of Homer. On deck were olives and vines, planted in pots, and watered by pipes of hardened clay. The windows were thin sheets of fine ivory. She had bathing coppers for holding water; one held 250 quarts, and a tank or reservoir at the forecastle held 100,000 quarts. All round this ship outside were a row of atlases of six cubits, *i.e.*, nine feet high, placed equidistant. She had eight towers for archers and slingers, and an engine (constructed by Archimedes) which flung stones of three hundred-weight. All round her were irons for grappling the galleys of an enemy. Her hold was extremely deep, but one man sufficed to keep it clear of water "with a machine made in the nature of a *screw* by Archimedes." When finished, no port in Sicily could hold this great ship, so, as there was a scarcity in Egypt, she was laden with grain and sent as a present to Ptolemy Philadelphus. Such is the description given of her by Athenæus, who unfortunately left no record of her dimensions.

When Marcellus, the Roman consul, besieged Syracuse, the inventions of Archimedes enabled the citizens to protract the defence for three years; and so sensible was the consul of the value of the philosopher, that he gave strict orders, in the event of the town being stormed, that his soldiers "were not to hurt Archimedes, and he even offered a reward to those who should bring him alive and safe into his presence."

To Appius he assigned the command of the land forces, and reserved to himself that of the fleet, which consisted of sixty galleys, each having five benches of oars, armed with soldiers, chiefly archers and slingers to scour the walls. On their decks were many of the cumbrous battering machines used prior to the invention of cannon. Finding themselves assailed by sea as well as land, the Syracuse were filled with considerable trepidation; and but for Archimedes, to whom the defence was assigned by Hiero, their resistance would have been small. Machines constructed by him hurled upon the Roman infantry showers of darts and stones that were of enormous size, and which went whizzing through the air with a startling sound. They beat down or dashed to pieces all that came in their way, and occasioned the greatest disorder in the close ranks of the legions.

Marcellus fared no better by sea. The balistæ and catapultæ of Archimedes had all longer ranges than those of the Romans, and baffled the attempts of their best engineers. Nor were these their greatest danger. "Archimedes had placed lofty and strong machines behind the walls, which suddenly letting fall vast beams with an immense weight at the end of them, upon the ships, crushed and sunk them to the bottom. Besides this, he caused an iron grapple to be let out by a chain: the person who guided the machine having caught hold of the prow of a ship with this hook, by means of a lever-weight let down within the walls, it was lifted up and set on its stern, and then by letting go the chain either by wheel or pulley, it was let fall again with its whole weight either on its head or side, and often entirely sunk. At other times his machines dragged the ship towards the shore by cords and hooks, and after having made it *whirl about a great while*, dashed it to pieces against the rocks below the walls, destroying all within it. Galleys frequently seized and suspended in the air, were whirled about with rapidity, exhibiting a dreadful sight to the spectators, after which they were permitted to fall into the sea, when they sank to the bottom with all that were in them."

Archimedes also constructed loopholes in the walls; at these he placed scorpions, machines in the nature of crossbows for discharging darts, and Marcellus began to be at a loss what to do. "Shall we persist," said he to his soldiers and engineers, "in making war on this Briareus of a geometrician, who treats my galleys and sambucæ so roughly? He infinitely exceeds the fabled giants with their hundred hands, in his perpetual and surprising discharges upon us!"

The Romans at length became so intimidated that if they saw upon the walls "only a small cord or a little piece of wood," they would scatter and break their ranks, crying out that Archimedes was about to discharge some dreadful machine upon them; hence Marcellus soon had to convert the siege into a blockade, during which part of his fleet was destroyed by fire.

"A burning glass is spoken of as the means by which Archimedes is said to have burnt part of the Roman fleet," says Rollin. "That must have been an extraordinary invention; but as no ancient author mentions it, it is perhaps a modern tradition without any foundation. Burning glasses were known to antiquity, but not of that kind, which, indeed, seems impracticable."

Syracuse at present has two harbours, the smallest on the north-east of Ortygia. Tradition still shows here the exact site of the house of Archimedes, and also of the tower from whence he is said to have set fire to the Roman galleys by his burning glass—a concave speculum, with a focus of enormous length—as their vessels lay between him and the sun, in a direct line at noon.

Syracuse at last fell by storm, and Archimedes perished. The philosopher was so deeply immersed in some problem that he knew not that the town was taken till the sword of a Roman soldier was at his breast. Plutarch says the latter commanded him to follow him to Marcellus, and on Archimedes refusing till his problem was solved, he was instantly slain. Livy says he was slain by a soldier who did not know him, as he was drawing a diagram in the dust. Marcellus sorrowed for this catastrophe, and interred him with honour under a tomb on which were carved a cylinder and sphere. This event occurred in the 143rd Olympiad, or about 212 years B.C.

Long subsequently, when Cicero was quæstor in Sicily, curiosity prompted him to search for the tomb of Archimedes, and, after many efforts, he tells us, that among a great many tombs without the gate of the city, facing Agrigentum, there was found a pillar almost entirely covered by thorns and brambles, but thereon were the sphere and cylinder! The inscription was still legible, though partly obliterated by time, and Cicero ordered the place to be cleared and the tomb respected.

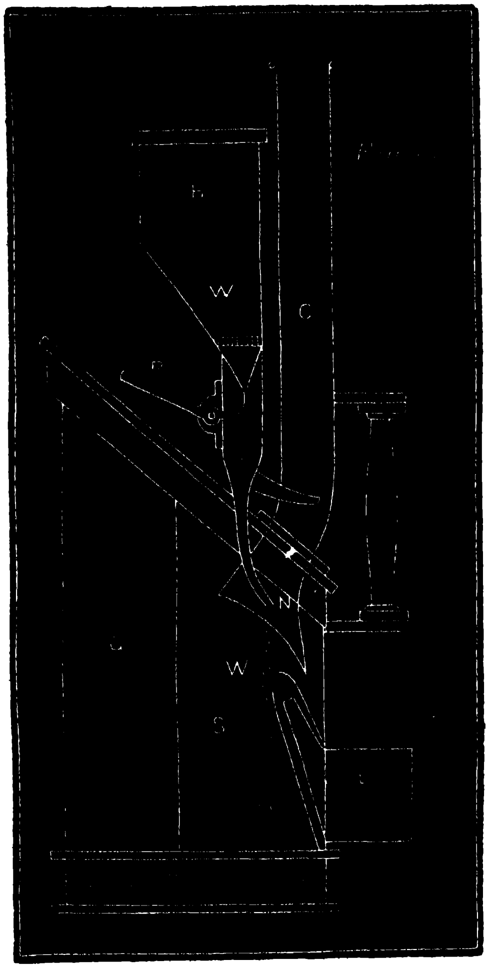
Excavated from a bed of native rock, the face of which, naturally projecting, is shaped about the opening into a rude Doric front, with rich pilasters and a pediment, the tomb of the great geometrician may still be seen at Syracuse, where at this hour the walls of the Conversazione Room are covered with pictures of his mechanical exploits.

OPTICAL INSTRUMENTS.—XIX.

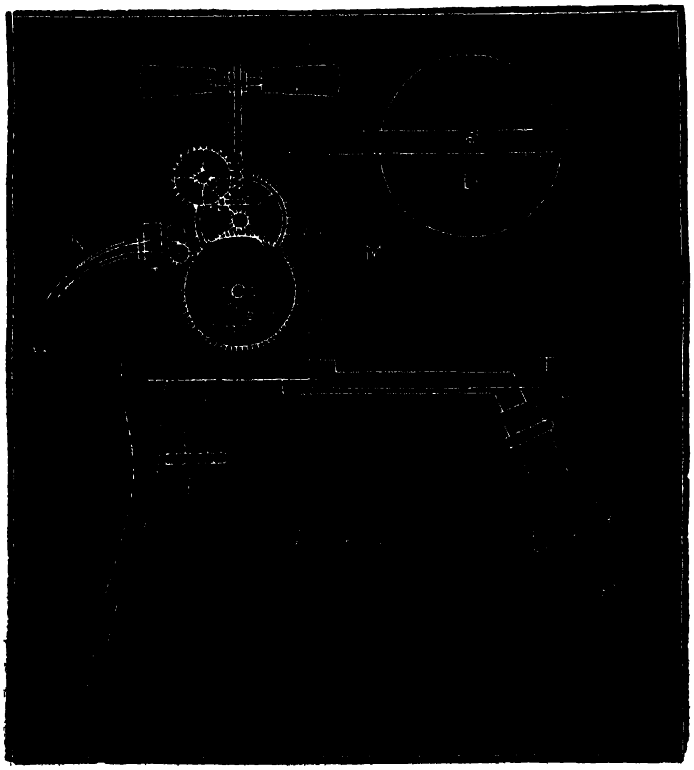
BY SAMUEL HIGHLEY, F.G.S., ETC.

SOURCES OF ARTIFICIAL LIGHT (*continued*).

Magnesium Light.—Next in convenience to the lights previously described is that produced by the combustion of the metal magnesium, which for intensity is almost equal to that of the electric arc, but from its flickering nature, and the large amount of magnesia vapour given off during the operation, its application for long-continued use is as yet impracticable; moreover, it is not so purely white as either the electric or lime lights, being characterised by a bluish tint that reminds



one of moonlight. As, however, this source of light is rich in actinic or chemically active rays, it is peculiarly well adapted for photographic operations, where a beam of light of a few minutes' duration is usually sufficient. The magnesium light has been recommended by some persons for magic lantern purposes, but no practised exhibitor would endorse such advice, for the reasons that a cumbrous coil or length of chimney-piping is required to carry the magnesia vapour from the lantern to a fireplace, or some other suitable up-draught, probably separated from each other by a distance of many feet; and, secondly, because whether we use single or multiple strands of magnesium wire or ribbon during the act of combustion, these twist into a corkscrew-like spiral, that causes the point of light not only to vary as to position but also as to brilliancy, till this oxidised part falls away of its own accord, or is broken away mechanically. Were it not for these drawbacks, which as yet have not been surmounted, this source of light would strongly recommend itself to the physical investigator and demonstrator, as the preparation of the magnesium light apparatus is of the simplest character, and involves no bulky or expensive appliances or accessories, as will be seen by the description of the apparatus and its manipulation presently to be given. The metal magnesium, discovered in microscopic quantities by Sir Humphry Davy in 1808, during his experiments on the electric deposition of alkaline metals on the electrodes of a voltaic battery, has, through the progressive investigations of Bussy, Deville and Caron, Bunsen and Roscoe, and Sonstadt, in recent years, been produced on a commercial scale that allows of this once very costly metal being supplied at somewhat over double the cost of silver, though it must be remembered that an ounce of magnesium is six times the bulk of an ounce of silver. In the early days of its manufacture on a commercial scale, magnesium was supplied in the form of wire, but more recently in that of a flat narrow ribbon, which is more convenient for manipulation; it is also sold in the form of powder or filings. Magnesium ignites at the temperature at which glass melts, and, besides giving off clouds of vapour, leaves a white ash, which is pure magnesia. It has been determined, photometrically, that a very fine magnesium wire emits a light equal to that given by seventy-four stearine candles of five to the pound. It may here be remarked that zinc presents very much the same photogenic characteristics as magnesium, and is used as an alloy to allow of magnesium ribbon being sold at a cheaper rate than pure magnesium would admit of, without detracting from its efficiency for light-giving purposes. There are two arrangements for burning magnesium: one for the delivery of this body in the form of a ribbon, the other in the state of powder when mixed with fine silver sand. The best lamp constructed on the first principle is that patented by Mr. Solomon, of Red Lion Square, and is that generally adopted by operators. The other arrangement is that invented and patented by the late Mr. Richard Larkin.



Solomon's Magnesium Lamp is shown in Fig. 82. The mechanism consists of a narrow drum enclosed between two discs of metal, D, capable of holding one ounce of magnesium ribbon when coiled up like a watch-spring, M, which rotates freely on an axis supported by arms that clamp on to a metal case that holds a driving-clock, C. This clock consists of a train of wheels which can be set in motion by a clock-spring, and in turn these rotate, by means of a connecting cog-wheel, a pair of delivery-rollers, between which the end of the magnesium ribbon is introduced, and by their action is passed through the curved nozzle, N, at which point the magnesium is ignited by means of a spirit-lamp. The ribbon should be paid out at the rate of combustion, viz., one yard in three minutes, and the clockwork is adjusted for this, by the suitable inclination of two regulating fans, F. The clockwork is wound up by a key attached to the side of the metal case, and is set in motion or stopped by raising or depressing a lever, T. This part of the apparatus is supported on a tripod stand, of which one leg forms a handle, H, by which it can be carried, or the light directed to any desired point. This lamp is charged by unscrewing a nut that clamps the drum, D, to its supports, and allows of its removal. One side-plate of the drum is then unscrewed, a coil of magnesium ribbon is placed over the drum, the tape that confines it cut and removed, and the inner end of the ribbon twisted and fixed to the drum itself. The side-plate is then replaced, and the drum fitted between its supports, care being taken that the ribbon is placed so that it unwinds from *the bottom*, as shown in Fig. 82, for if placed in reversed position, so that it unwinds from the top, it is liable to drag and get displaced. When the clockwork is in motion, introduce the end of the ribbon through an orifice in the back of the clock-case, press it forward till it is gripped by the delivery-rollers and is passed through the end of the nozzle, when the motion must be stopped by the lever, T, till such time as the light is to be brought into operation. This is the arrangement in its simplest form, but it may be made to deliver two or four ribbons. The clockwork may be arranged to run for a few minutes, for fifteen minutes, or for an hour, according to requirement; for short exposures, as in photographing sculpture, portraiture, copying pictures, etc.; or for longer exposures, when buildings, caverns, mines, etc., have to be lighted up; or the requirements of theatrical effect, military and naval signalling, or fishing or diving purposes. The delivery apparatus may be fitted with a silvered concave mirror, for concentrated light, or a flat reflector for diffused light, as shown in Fig. 83, for indoor use; or it may be fitted with a glass front and a chimney, as shown in Fig. 84, for outdoor use, or in places where it is desirable to carry off the magnesia vapour. It is very convenient to have an ashpan filled with water placed a few inches below the nozzle, into which the magnesia ash falls, and, moreover, this aids in freeing the ribbon from its spiral excrescence that is so detrimental to the more extensive applicability of magnesium ribbon lamps.

Larkin's Magnesium Lamp is shown in Fig. 85; it consists of a funnel-shaped hopper, H, in which is placed the mixture of magnesium powder and silver sand, W, the latter being added in such proportion as to assist a steady flow of the combustible metal, and in a divided state, so as to present a spirit-lamp flame in the best condition for perfect and rapid combustion. The bottom of this hopper is floored by a wire-gauze sieve, and closed by a conical plug fixed at the end of a pivoted arm, P, that, acting like a trigger, allows of the end of the hopper, H, being opened at pleasure, and the powder dropping down and out by a nozzle, N, that is placed directly over *the centre of the flame* of a spirit-lamp, L, the wick of which is placed out of the range of the falling powder. Both the hopper, H, and the spirit-lamp, L, are affixed to the metal framework of a closed lantern, S, the front of which is glazed with a sheet of curved glass, G. A tubular chimney, C, is fixed to the top of the lantern to carry off the fumes, and a conical metal shield springs from the bottom of the framework to guard the wick of the spirit-lamp. A stiff loop of wire is fitted over the nozzle-tube, and by a lever action scrapes off any incrustation of magnesia that may be deposited on the nozzle, N, in a way to impede the proper flow of the powder through the flame. The continuance of the flame depends upon the opening and shutting of the conical valve, P, or the exhaustion of the charge of magnesium powder placed in the hopper. This form of lamp is best suited for signalling purposes, as well as for photographic and illuminating requirements. A larger form of this arrangement was employed at the Nottingham meeting of the British Association for lighting up a large refreshment tent and a garden attached thereto, two lamps being sufficient for the purpose.

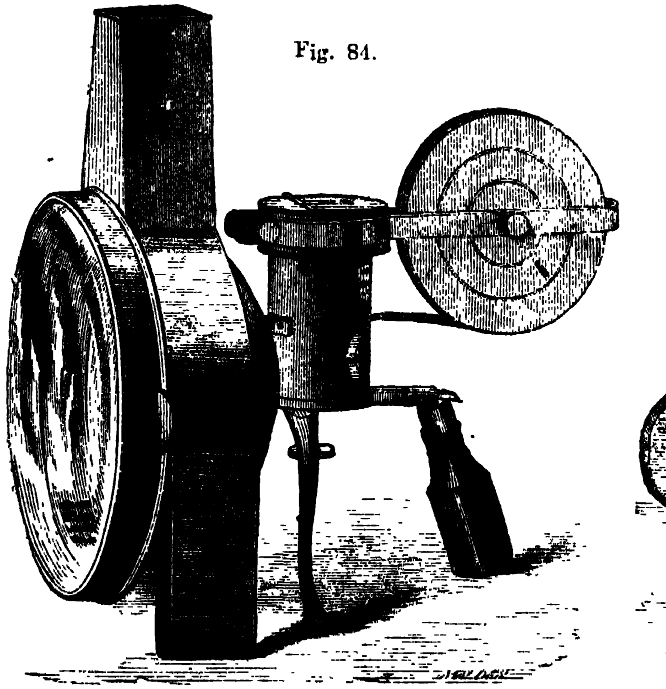


Fig. 84.

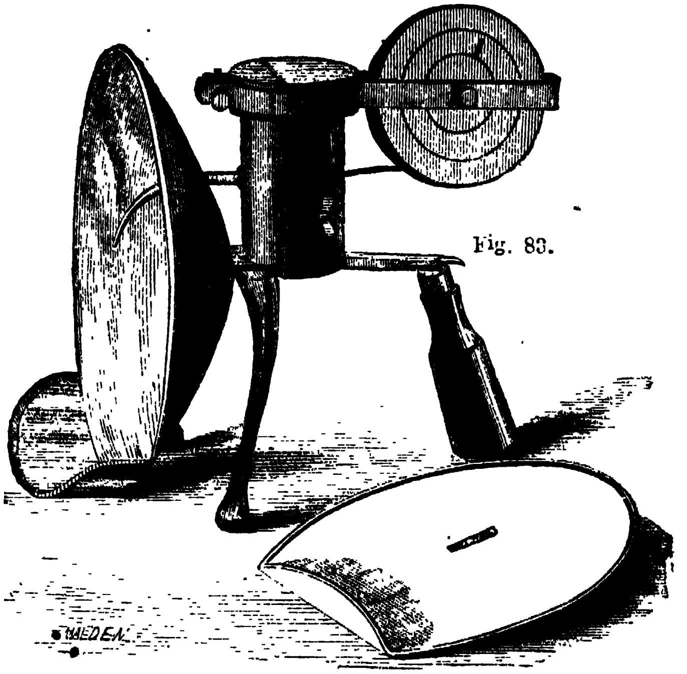


Fig. 83.

Magnesium Photogen.—For certain photographic operations, such as taking portraits of the living or dead, by means of small cameras and lenses, in rooms where sufficient sunlight is not attainable, and especially in *photo-micrography* (photographic delineation or enlargement of microscopic objects) or *micro-photography* (production of minute photographs), the method of producing the requisite amount of actinic effect upon the prepared surface by means of a definite charge of light-producing material strongly recommends itself. This method is best carried out by mixing, shortly before use, 72 parts of magnesium powder with 122 parts of dry chlorate of potash in powder, and determining by experiment how many grains of this mixture will produce the necessary action, by a given photographic process, with the particular kind of apparatus employed. The determined quantity may be termed "the standard photogenic charge," and more or less than this may be used according to the actinic or non-actinic character of the object to be photographed by artificial light. For instance, in taking photo-micrographs, if the object is of a blue or violet tint, less—if yellow or red, more—than the standard charge may be used. The required quantity of "magnesium photogen" should be piled in a conical heap on a little metal saucer mounted on a telescopic stand, placed in the focus of a parabolic or concave mirror adjusted to the optical axis of the apparatus employed, and be lighted with a lucifer match when all is in arrangement for the exposure. If working with photographic dry plates, it is a good plan to use three in succession, one being exposed to the full standard charge, the others to the minimum and maximum charges; between the three, and by judicious development, a good result should be attained. Magnesium powder may be obtained at half the price of the ribbon, and whatever arrangement is adopted, a photographic impression may be produced on a prepared surface for a cost that does not exceed twopence, with a source of light that is little inferior in actinic power to the sun itself, and is ever at command, night or day. Magnesium powder is now extensively used in the manufacture of fireworks, as may be noted by those who have seen the magnificent pyrotechnic displays at the Crystal Palace.

Photography and the magnesium light may be taken conjointly as an admirable example of the progress of science and scientific knowledge during the nineteenth century. At its commencement we were indebted entirely to the eye and hand of man for the pictorial representation of any object. The art of photography was then discovered, by which an accurate picture of an object was obtained by means of the sun's rays reflected from its surface; and now the brilliant magnesium light renders us independent even of the sun itself for the production of pictures by the agency of light.

FISH CULTURE.—VIII.

By Greville Fennell.

PROPER NATURAL FOODS FOR YOUNG FISH—FENCE MONTHS—METHOD OF TAKING EGGS FROM SALMON—THE WATER-OUZEL.

While speaking of proper foods for newly-hatched fish, we may remark that another excellent natural food at this time is the larvæ of the common gnat (*Culex pipiens*), which also hatch out in the water, but, contrary to the *Simulia*, only in stagnant pools filled with rotting plants. The *Simulia* lay their eggs crawling down to the stalks of the plants in the water. Their development is very rapid, and in every ditch and flooded meadow, in every puddle, the larvæ will be found throughout the year in quantities. It is advisable to make some pools for breeding gnats' larvæ so arranged near the feeding ponds that the food may be taken direct. Another very good food is the fresh-water worm (*Nais*), very thin and red in colour; these either swim about in stagnant waters or lie in the mud in masses, from which they may be collected with a narrow mesh wire net which is distended round a strong ring. Fed on these water-larvæ and worms, the fish grow rapidly, and in the last weeks the young fish should be supplied with plenty of tadpoles, the larvæ of toads and frogs.

The great grass frog (*Rana temporaria*) lays its eggs in March. At the end of that month and beginning of April, the tadpoles are found everywhere in stagnant water. If at the proper time the great shining lumps of spawn, of which whole barrowsful can be collected in a few hours from adjacent waters, be brought to a small pond shaded from the sun, and provided with decaying plants, near the establishment, in a few days the tadpoles will hatch out, and there will be an ample supply of food for the rest of the feeding-time. As it will occur that some of the young fish, being better feeders, will be double the size of others, it is advisable to place them in a separate basin, otherwise they will take too much food from the rest, and prevent their development."

An element in the success of the cheapening of salmon is almost essentially a fishmonger's question. As with coal-owners and all large monopolists, their interest is to keep up the price, and this they do to a certain assured extent by the assistance of the telegraph, and a well-considered system of agencies which directs the fish only to those several markets where a demand sufficient to ensure the maximum price exists, the saleman and tacksman both combining to keep back the salmon in the cruves in their natural element, or in ice on land until such times as the inducement to transit arrives at a fixed and agreed standard. This is now so well known that no longer is any secrecy involved in the matter, and it appears fair enough between consumer and producer; but a bountiful Providence frequently defeats even the best of man's schemes, and in times of great plenty the desire for high prices is merged in the aggregate returns; and this would be still more the case if we could remove all obstacles to the breeding of salmon, and thus make the very weight of the takes force out of view the present selfish ends of the tacksman, who would still obtain the same profits, but not at the expense, so to speak, of the public, for there is even a minimum to be reached in the price of salmon below which it can scarcely go, unless close to the scenes of its capture.

While upon this point we may state from high authority that a plan is in contemplation to make fish-salesmen take out a licence if they sell salmon, as for selling game. Thus, although the annual impost would not be large, and scarcely felt by the dealer, it would produce a great income, which should be devoted towards building salmon ladders over weirs and other obstructions, and providing funds for paying watchers during the winter. This would tend materially to multiply the number of salmon, and enable the commissioners who are now poor in funds to carry out preservation with greater strictness and effect.

Fish culture being a subject which has occupied many volumes and yet has not been exhausted, some allowance must be made here for all omissions and shortcomings. We have, however, done our best to give as much detail of the processes pursued and as general a view of the present state of fish culture in this and other countries as our space would permit. Those who would follow up the subject yet closer should refer, besides the works of which we have made mention, to "Historique sur Établissement de Pisciculture de Huningue," Strasburg, published by Berger-Levault, 1862; "The Salmon Fisheries of England, 1868. From authentic information obtained for the House of Commons. To which is added valuable and exclusive information extracted from the Reports of the Commissioners of Fisheries in France, America, Norway, and Russia. By Thomas Ashworth, Esq." London: Longman, Green, and Co. Bath: William Lewis, "Directory" Office.

No man who aspires to the character of an angler would ever destroy the fry of salmon or take any migratory species that has not been down once to the sea, and owners of fisheries cannot be too vigilant in putting down all unlawful nets or engines, as these instruments of wholesale slaughter do more harm in a few hours than the whole of the fair fishing put together.

The trout grows remarkably fast in the Thames, and is tolerably good food when in its prime. But angling is permitted far too early for this valuable fish, it being often captured in March, when, after spawning, its appetite being voracious, it is made an easy prey by the impatient angler. This thoughtlessness of the fisher cannot be too strongly denounced. All remonstrance, however, appears in vain, for as long ago as 1840 a writer upon angling literature used very strong terms with a view of putting a stop to the system. "Thames anglers," he said, "begin to fish too early in the season: by spinning a minnow or bleak in the month of March, they may take a ten-pounder, which is not uncommon, and then they boast of having captured a fine fish, whereas, in fact, it is only fit to be thrown away, being full of worms and flabby flesh. Were such a fish left for three months longer, it would not only have increased in weight, but it would have been worth something considerable, as it would have been in season. In taking a trout at that time, there is neither art nor science, the fish being still so weak from spawning—for large fish spawn very late—that it has not the power to contend against the rod and line, which it would have had in June."

Fence months, in all waters whatever, should be rigidly observed. The strictest attention and watchfulness is then required, not only to the parent fish, but the brood, for it is at that time the young of salmon may be taken by the most simple contrivances, and pike more particularly—the nature of which is to run up ditches and shallow tributaries to spawn—will then allow themselves to be snared by the wire of the most stupid plough-boy. The destruction of under-sized fish in the Thames has very properly received the attention of the officers and water-bailiffs of the Thames Angling Protection Society, and nothing can serve better to demonstrate the fact that the small fish of the present year are the takeable and appreciable stock of the next, than the marked increase in size and weight this season (1871) over that of last year, the fish in the interim having been protected by extra vigilance and the infringement of the bye-laws very properly carried out by the punishment of the delinquents. Mr. Boccius, when writing some years ago upon this point, observed that not only with regard to trout and salmon was the want of a proper system of protection forcibly felt, but this same shield of protection is wanted in all rivers for all other fresh-water fish; for were the artificial principle and protective arrangements extended to them, their increase would be enormous. In that part of the Colne, for example, which this gentleman laid down and attended to, even roach grow to the great weight of from one and a half to two pounds in their fourth season, and this weight was almost unprecedented elsewhere. This shows at once what protection, which means constant and methodical watchfulness, will do for fisheries; and that fisheries, like farms, when looked after systematically, will flourish, but when neglected, will fail.

Where trout and grayling are the objects of care, the streams should be dragged two or three times in a season to get rid of the coarse fish and give room to the rising brood of the better class. Indeed, all streams are the better for an occasional clearance of the large pike, even in pike preserves, and if they are not immediately needed for the table they should be kept in stews and fed upon roach, dace, and bream, which in comparison are worthless.

We are reminded in looking through our preceding papers, that although we have spoken of the method of dealing with a trout by holding it when full of spawn in the attitude shown in Fig. 6 (Vol. II., page 353), when the ova, if ripe, will drop down in a mass towards the vent, the operator would find it somewhat difficult to hold a salmon in that position. Mr. Francis Francis tells us that, with a large and vigorous salmon, it has required at least three men to hold it, and that then the task is not easy. "I have known a salmon," he writes, "in its struggles send pots, pans, water, and ova flying with one dash of his tail. The softness of the belly is the best test here. In grayling the belly is less soft, the fish being more of a hard and scaly nature generally. A slight pressure, however, if grayling or salmon or trout be at all ripe, will usually be sufficient to extrude two or three eggs, when the fish should be carefully put up until all preliminaries are prepared for operation. How the fish are to be kept alive depends entirely upon the conveniences at hand. In some rivers a little pool can often be made at the river's side; in others, pails or even washing-trays are used. A salmon can be tailed—that is, tied up - by means of a cord, a slip knot being passed over the tail. A male or female fish being secured, obtain one of the other sex as soon as possible." Mr. Francis adds "that it is always as well, if they can be had without difficulty, to retain two males to one ripe female, in case of a scarcity of milt."

It must still be understood that we are now treating of salmon—not trout or manageable fish. "The requisites for spawning the salmon properly are, first, a shallow open dish, with a lift to it (this dish should not be less than twelve or thirteen inches square at the least); a large jug for fresh water; and a tin can, with a perforated lid, to carry the ova in (this should be a can capable of holding at least a gallon of water). First half fill the dish with clean water; take the female, one person holding the head and another the tail and if necessary a third steadying the body. If the head be held between the knees, a better hold will be got; and if a *dry* cloth be used to hold the fish, there will be less chance of her slipping. Now, the fish being held with her tail downwards and the body rather sideways, or with the belly a little towards the operator, the vent being as closely over the water in the tin dish as may be convenient, the manipulator should, steadying the fish with one hand, compress the body with the other, passing the finger and thumb upon either side with a gentle pressure from the thorax down to the vent. This pressure, be it remarked, must not be harder than is sufficient to expel the eggs without difficulty. If the fish does not give up her roe, no force must be used; but lay her aside on the grass, or even in the water, for a few minutes, when, perhaps, she may be more easily persuaded. If, however, she declines, she is not quite ripe enough; and if you have the means of keeping her for twenty-four hours, or forty-eight hours, it will be advisable to do so. But, I repeat *no force must be employed*."

It may not be out of place here to remark that, in proof of the practical, not to say commercial, shape which pisciculture has taken, an establishment has been opened at the Trouldale Fishery, near Keswick, Cumberland, under the management of Messrs. Joseph J. Armistead and John Parnaby, for the distribution of ova of various fish throughout the country. But to show to what an extent Messrs. Francis Francis, Buckland, Youell, Ponder, and others have been unselfishly inspired by their gratuitous aid to fish culture, we quote from the tariff of this firm:—"American trout fry, £100 per 1,000; black bass fry, £100 per 1,000; Canadian *fresh-water* salmon trout fry, £100 per 1,000; trout ova, 50s. per 1,000; and trout fry, 60s. per 1,000." Let us hope that there will yet be a more substantial recognition of the services of these gentlemen, from Tasmania and elsewhere, than their most important labours have hitherto elicited.

Let us say one word at parting for the water-ouzel, which has most wrongly been classed amongst the enemies of fish ova. It is strange to say that this prejudice still obtains, realising the old axiom of "Give a dog a bad name and hang him." Yet the Zoological Society, so far back as 1863—many years, as events succeed each other now—having fairly put the water-ouzel upon its trial as a notorious destroyer of fish spawn, the first verdict was "Not proven." This being the form of a Scotch verdict, an English water-ouzel was entitled to enter a demurrer. We are therefore not surprised to learn that a distinguished ornithologist objected to it, and that the jury ultimately returned their verdict thus: "Water-ouzel *fully* acquitted of the charge of eating fish spawn." The fact is the water-ouzel frequents the spawning-beds in order to prey upon the insects which feed on the ova of the fish; so that in our merciless ignorance we have been killing a piscicultural friend every time we shot a water-ouzel—just as we believe the farmer hangs a friend every time he traps a mole, or drives a host of well-wishers away by employing a boy to frighten the rooks from eating the larva of the cockchafers and daddy-long-legs.

The elastic toughness of the ova has been before observed upon, but it should be pointed out that this considerably facilitates the transport of fish ova for the purposes of pisciculture; and experience has demonstrated, principally through the perseverance and judgment of Mr. Youell, that they can be safely transported for any distance which can be travelled, either by land or water, in the time during which the ova naturally remain unhatched. There is one simple rule which must, however, be insisted upon—never to attempt the removal of ova till the eyes of the fish are plainly seen in the egg.

In reference to the food of fish, and the necessity to encourage the growth and increase of such food as fish must profit upon and delight in, Mr. Francis, in his "Fish Culture," has some highly suggestive and important observations. "We should know what kind of food suits our various fish best, and what conditions best produce that food, and how these conditions are best to be cultivated, so that such food may be self-producing." The chapter from which we quote, on the food and its production, demonstrates in a very interesting manner how great is our ignorance of this department of knowledge. "There is not an insect or small reptile that inhabits the soil beneath us, or the waters around us, that is not food for fishes in a greater or less degree. Worms of all kinds, flies, grubs larvæ, cockchafers, crickets, leeches, snails, humble-bees, birds, mice, rats, all serve the turn of one fish or another, and so in turn help to produce food for man. Nothing living comes amiss, but doubtless some kinds of food agree with them far better than others. But we know very little on this branch of the subject. It is dreamland to us, with a very little waking reality." Some rivers produce larger trout than others, like them in all visible features. Mr. Francis compares the trout of the Chess, a branch of the Buckinghamshire Colne, with those of the Wick, little more than a good-sized brook, near High Wycombe. The may-fly abounds on the Chess, but is hardly seen on the Wick, and yet the Wycombe fish, attaining a size of from seven up to even ten pounds, and of a red colour deeper than salmon, is decidedly superior. Why? How is it that this little stream had not—for we fear sewage has even here done its deadly work—its equal in all England for the size and flavour of its trout? Mr. Francis surmises—and from our own experience of these waters we would think correctly so—that the fresh-water pulex or screw has not a little to do with the production of this marked superiority. "I have seen," says he, "the trout picking them at the walls which part the stream in some places, as rapidly as a child would pick blackberries from a hedge; and I am induced to think that this insect has much to do with the fineness of the fish; and the more so because when I have found it exist in any quantity, I have invariably observed that the trout are of fine size and in unusually good condition."

Happily there exist signs of an advancement of knowledge in the direction here under review. The intelligent angler now no longer takes for granted the clumsy and libellous imitations of insect life which are offered to him with commercial confidence by the tackle maker; but his observations as a naturalist being sufficiently advanced, he searches for and obtains the flies indigenous to the stream he is about to fish, and, as close as art can aid him, simulates the natural object. Mr. Francis Francis "Book on Angling" points out how close is, or ought to be allied, the entomologist and the fisher; and that, although the angler may possibly be of service to the naturalist, a study of such works as the Rev. J. G. Wood's "Insects at Home," cannot fail of being highly advantageous to the angler. In a word, that all knowledge is so intimately blended that the acquirement of any one department must inevitably enhance the value of the others; and, as here shown, an acquaintance with the precise fattening food of fish and its use would materially tend to their sustenance and consequent increase.

In a future paper we hope to make some remarks and offer some instruction on the methods adopted for propagating and feeding such shell-fish as oysters, mussels, etc.; a kind of fish culture which is followed up with spirit in some parts of the Continent, and which might be carried out far more than it is in our own country as a profitable employment.

PRACTICAL APPLICATION OF THE FINE ARTS.—X.

THE ART OF MOSAIC (*continued*).

By P. H. Delamotte, Professor of Drawing, King's College, London.

We have already classified mosaic work according to the materials employed, and the manner of using those materials. We now intend to arrange mosaic work more according to the art shown than the style of workmanship displayed. We have also in a previous paper noted that the spread of Christianity had a vast influence on the character of the designs and the spirit in which they were carried out. This and many other political and social changes had their effect upon mosaic as well as upon other arts, and the various phases of the art thus produced have been divided into seven periods by Sir Digby Wyatt, whose exhaustive treatises we shall in the main follow.

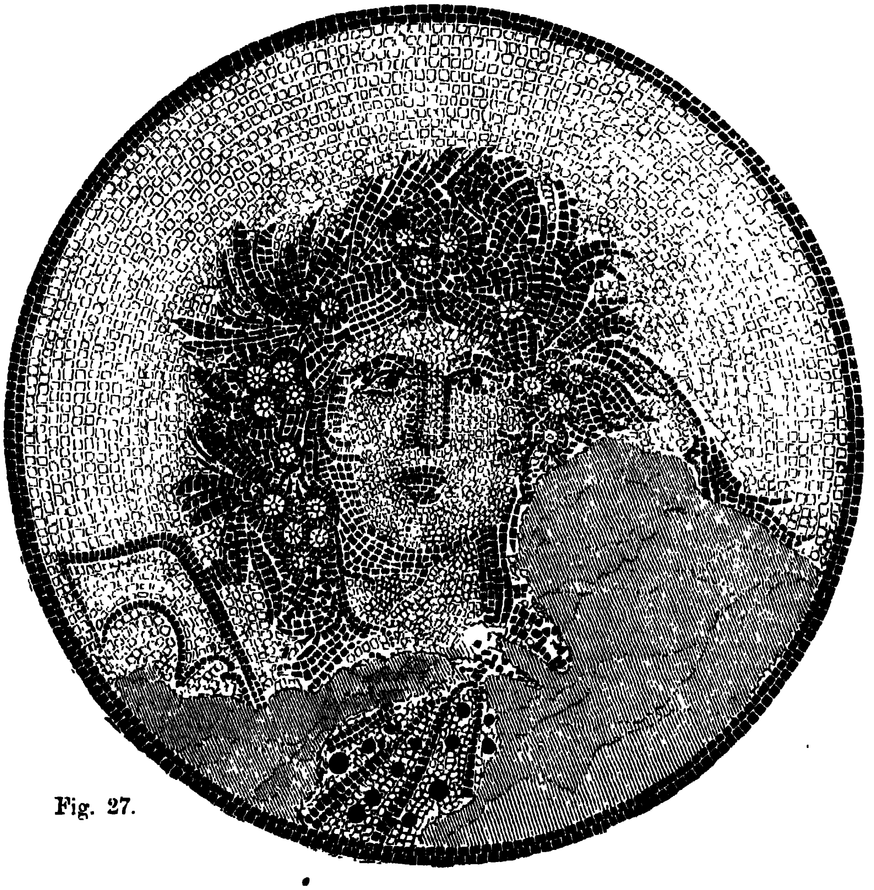


Fig. 27.

The period to which he gives the name of *Classical* is traceable from the earliest times down to the general decadence of the empire. Two distinct schools of taste are traceable in this work; the one, belonging to what is usually called the Græco-Latin race, delights in figures of red or buff upon black grounds, or delicately coloured designs upon a flat tint of some depth of colour—naturally the designs of this school more or less resemble the style of decoration common amongst the severest artists of the two great peninsulas, viz., the Etrurians and the Dorians, and it also keeps up the connection which the latter show with Egypt; the other school is derivable from the East, and partakes of the magnificences of Babylonia, Assyria, Phœnicia, and Asia Minor. In all the work of this period we find large surfaces of even colour, and we notice that there is no attempt to conceal the ultimate fact of mosaic—viz., that it is made up of many small cubes. The joints are not hidden by coloured cement, nor are the tesseræ of any great size, but a uniform tone is produced at a moderate distance by the combination of these materials. This is true art, and should be aimed at in artistic workmanship. The materials should be used with judgment, certainly, but as the materials they are, neither concealing their natural imperfection, nor aiming at representing what they are not. It was just in the same way that we recommended the judicious use of the leading and the iron stanchions in glass painting, making the lines of the leading follow as much as possible the outlines of the design, but not scrupling for one moment to allow either lead or stanchion boldly to pass through the midst of flat colour if the necessity arose for it. So in mosaic designs the natural imperfection of the joint between the tesseræ should be recognised and used, and adapted to the circumstances of the case. A pleasing, even flat surface is produced by the regular disposition of evenly-sized cubes, whereas the contours of the figures, etc., are more thoroughly made natural to the eye by one or two lines of tesseræ following more or less the directions of the outlines. The study of ancient work of this period is of great importance to those who would carry this work to perfection, and fortunately for us the numerous remains in this country afford the means for this study. We have already given examples from the pavement at Cirencester; we here show two heads of great boldness of character. The very roughness of the outlines show how much power and grace can be obtained by unwieldy materials if treated in accordance with their nature. The British Museum and many local museums afford frequent examples from various parts of England, and these are deserving the attention of those interested in the cultivation of true art.

As we have here given two heads from the pavement at Cirencester, it may perhaps not be out of place here to mention the colours that we are unable to give in our woodcuts. In both heads the greater part of the flesh colour was produced by the cream colour of a fine hard freestone; this is heightened by a little yellow and some borderings of red, whilst the shadows are represented by the deep chocolate of red sandstone, and many of the outlines are of black terra-cotta. The hook of Ceres (Fig. 27) is of a dark bluish-grey, while the ears of corn adorning her head are produced by black and yellow; between these are interspersed dark olive-green leaves. The hair is black. In the head of Flora (Fig. 28) the flowers are of a bright ruby red, produced by tesseræ of glass coloured with copper. The leaves and stems are of the same dull olive-green as in the other head. One or two white flowers are introduced in the dark chocolate-coloured hair. The swallow on her shoulder is simply black and white, with one line of grey. Fig. 29 is a portion of the border round the head of Flora.

Another head, given in the last article (Fig. 18), is from the baths of Agrippa at Rome. Though of a coarser character of work, it still more clearly shows a complete mastery over the materials, and it is an especially good instance of the peculiarity we have noted above of the lines of the tesseræ following those of the design.

The second phase of mosaic work has been called *Latin*, and extends from the reign of Constantine at the beginning of the fourth century to the middle of the thirteenth. It is not confined to Italy, but is to be found wherever the Latin race spread their dominions, and is especially to be sought for amongst those nations that have retained an impress of the Latin language, institutions, and laws. It is distinguished by an absence of all Byzantine influence, but shows on the other hand strong traces of the race amongst which it was most in vogue. In this variety of mosaic we meet with very much work that reminds us of the classical period—even in many cases the ornamental borderings and divisions are the same. Fine specimens exist in the pavement of the cathedral of Novara, in the crypt and choir of the church of St. Bertin at St. Omer, and in the monumental slab of Frumualdus, Bishop of Arras, formerly in the cathedral church of St. Waast, now deposited in the museum in that city.

Concurrently with this last phase we have another which has been named *Byzantine Mosaic.* This dates from the transfer of the empire to Constantinople in the fourth century, and does not appear to have flourished after the eighth. The first artists were transported from Rome by Constantine the Great, and their work naturally partakes of the character of that in their native country; but very soon an Eastern element developed itself, and this henceforth became the main characteristic. No doubt the finest specimens were originally to be found in Constantinople itself, but the remains at Ravenna, which in 404 A.D. became the capital of the Western Empire, and in 568 A.D. the capital of an exarchate under the Eastern emperors, now afford the finest examples we know; whilst San Marco, at Venice, carries on the taste once developed on the western coast of the Adriatic. In Ravenna the following churches all afford specimens of this class of work, and some of them are nearly covered with it—the two churches of San Apollinare, the one in the town, the other at a short distance from it, San Vitali, the tomb of Galla Placida, and the chapel attached to the archiepiscopal palace. Some of the work in Rome of this period shows a decided tendency to this school, though much of it is inferior to what had preceded it. The main characteristics are a gold background to be found everywhere, a calm dignity of expression, and a happy grouping of the figures.

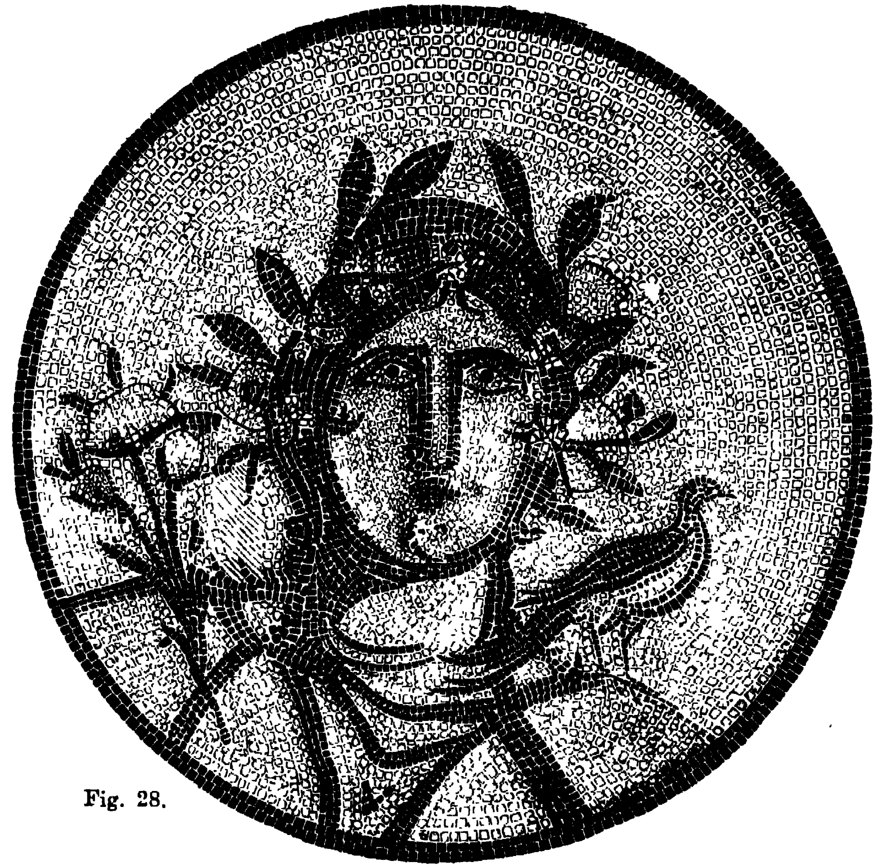


Fig. 28.

As we mentioned above, some of these churches are almost covered internally with pictorial representations, and thus they come to form a part of the original design of the building, and the arrangement of the pictures is made subservient to the general features of the architecture. It is in this way that the art arrives at its perfection. It finds its fitting place as one of the handmaids of architecture, and in this position it fulfils its highest office. Next after a study of the old classical work, in order to see how the technical difficulties of the material are to be overcome, we should most strongly recommend a systematic course of observations of the Byzantine art, more especially of Ravenna and Venice, for the student who desires to see the class of subjects most adapted to delineation in mosaic, and the mode of treatment which is applicable to this art.

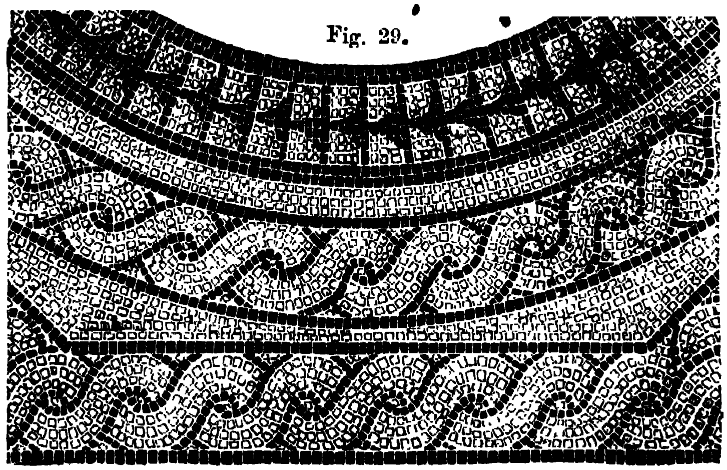


Fig. 29.

The *Græco-Italian* phase is the name given to the school developed by Greek artists on the congenial soil of Sicily, and carried on in that country during the time of the Norman kingdom. The cathedral of Monreale, begun 1174, is said to be the noblest and grandest instance of a church decorated entirely with mosaic, with the exception of St. Sophia at Constantinople, and San Marco at Venice.

The next class of mosaic work has been called the *Italian monumental*, and has for its principal seat Florence, the great artistic rival of Rome, though some splendid specimens are to be found in the latter city, especially in St. John Lateran and Sta. Maria Maggiore. We now come to the names of the artists who furnished designs for this work. The Florentines Andrea Tafi and Mino da Turrita learned the processes of the Greeks who worked in Venice, and Gaddo Gaddi afterwards carried on their work in that city; after which, in Rome, Pietro Cavallini and the Cosmati became celebrated. Thus the work was continued until the rise of fresco painting superseded its more costly but more permanent predecessor.

The production of work of the two remaining schools of mosaic, that Sir D. Wyatt calls the *Italian portable*, and the well-known *Florentine*, or *pietra dura*, has been carried down to the present day. By *portable* is intended that species which is really a continuation of the *opus vermiculatum minus*, and is principally employed to make copies of well-known masterpieces of great painters. The *pietra dura* is founded upon the *opus sectile* of the ancients, and is composed of the most durable materials matched according to their natural colours. Each piece is cut and ground into shape, and the thin slices are backed by pieces of slate or similar material.

In Rome and in Florence at the present day a large amount of work is done, and in Venice Signor Salviati has revived, to a great extent, the art well-nigh lost to his native town. In Rome the copying both of ancient mosaics, such as "Pliny's Doves" and of the masterpieces of pictorial art, form continuous employment for the skilled workman collected in the Papal establishment. The original object of the Popes in establishing workshops for the cultivation of mosaic, was that such pictures as Raffaelle's "Transfiguration," the "Madonna della Seggiola," etc., might be transferred to a durable material that would not only defy the power of light and time to diminish their colour or brilliancy, but also place such precious relics beyond the risks to which canvas and colour are ever liable. But to train men to the effective imitation of great works, it was necessary to practise them in smaller matters and on pictures of lesser note; hence arose a supply of works more within the compass of private individuals. It was no wonder that strangers in Rome, overwhelmed with the mighty works around, might wish to carry away some memorial of the precious relics of art which are the true objects to which devotion should be paid in the "slowly fading mistress of the world." A supply was afforded, and a demand arose for these works, and thus the Pope's workmen are trained for the work of supplying the great churches in Rome with imperishable copies of the greatest works of the greatest artists.

In Venice, as in Rome, a constant supply of work for mosaic-workers was afforded by the repairs required for San Marco; and Signor Salviati, a descendant of a house historically connected with art manufacture, having begun by restoring the manufacture of the glass for which Venice in the Middle Ages was celebrated, he continued his exertions in the cause of recreating lost arts, and having manufactured *smalti* such as was used by the ancient artists, he determined to cultivate the taste that had been displayed by them. Money being requisite, he obtained the necessary support from England, and in return he has sent to this country many excellent specimens of what he has been enabled to accomplish. The impetus given to architecture during the last twenty years has greatly influenced, as might have been expected, all the arts connected with architecture, and thus mosaic has again found the place which it once took among the kindred arts. In this matter Signor Salviati has done good service, since he not only has himself carried out much decoration with this material, so well adapted to permanent ornamentation, but he also prepares the material of which others can make use; and our own manufacturers of the terra-cotta tesseræ and the small tiles which can be introduced in various ways, avail themselves of his glass, and especially of the golden-covered glass so well adapted for backgrounds, and which the manufacturers in this country have as yet been unable to imitate.

SOLDIERING.—III.

BY A STAFF OFFICER.

EQUIPMENT OF AN ARMY—WEAPONS.

I HAVE said that we must constantly keep before us the fact that an army is an organism, the active energy of which depends on the nature of the spirit which pervades it. Nevertheless, as the object of the enrolment of an army is the development of physical power, it is all important for us to consider what material agencies can be employed to that end with the greatest effect. The two questions are so closely bound up together, that it is historically true that the changes in the nature of the agents employed have contributed more than any other cause gradually to change the nature of the discipline or prevailing spirit, by which armies are held together. The armies of our day differ essentially from those which existed previous to the invention of gunpowder. The field of study with reference to recent times is in itself vast. Hence it is unadvisable for one who would learn the condition of modern wars in the most perfect degree, to occupy himself long with armies of the earlier period. Obviously the great change is due to a difference of *equipment*. Till fire-arms were introduced the great object aimed at in a soldier's equipment was that of rendering it impervious to arrows, javelins, and lances. All such considerations were swept away by a weapon which drove its bolts through any weight of metal that men could carry, scarcely less easily than through broadcloth. Defensive armour almost entirely disappeared, and the conditions under which soldiers have now-a-days to be equipped present an altogether different aspect. I include under the general term equipment all that must be actually present with the fighting portion of the army at any one moment. We shall have to consider at a later stage how the army has to be provided with further supplies of its chief requisites.

The different portions of equipment may be conveniently classed under the following heads:—First, those which are required for actual fighting purposes; secondly, clothing; and, lastly, such necessaries as it is indispensable that the fighting part of the army should have actually at hand.

First, as to the weapons we now employ. I need not dwell on the details of the subject, for a full description of all of them has been given in papers of THE TECHNICAL EDUCATOR specially devoted to that purpose. But they concern us here in so far as their special characteristics affect the question of organisation.

We have, then, two great classes of fire-arms. First, as being in fact the more important, the small-arm; and secondly, the big guns: the one such as a man can carry; the other comprising all guns beyond that size up to the most enormous piece of ordnance which can be invented. The progress of improvement in fire-arms has gradually reduced to an altogether secondary importance all other kinds of weapons. I say it has "gradually" brought this about, because we do still employ hand-to-hand weapons in fighting. The bayonet, the sword, the lance are still in use; but, as time has gone on, the employment of all these weapons has receded in importance, and battles are more and more fought out with fire-arms, all other weapons being only accessory.

One other agent, however, the value and force of which has been appreciated from the earliest times, remains almost as important as ever, if its action on the whole be taken into account, though that is scarcely true of its present effect in mere fighting. The horse has been always employed by man for innumerable purposes in war, but in his special use for actual fighting purposes his action is so important, that in order to take full advantage of it we continue in this one instance to employ hand-to-hand weapons as those of primary importance, fire-arms only for secondary objects. In the charge, in fact, the horse and man become themselves the projectile, of which the weapon held by the man is only the point or edge.

The subdivision of armies into the three so-called "arms" of the service—the "infantry," the "cavalry," and the "artillery"—is due to the necessity of employing effectively these several agents in war. The training which, as experience has taught us, is required for the soldiers who are to fight on foot, and who can be employed in using either fire-arms or hand-to-hand weapons, is necessarily very different from that either of the cavalry—the horse-soldiers; or of the artillery—those who are employed in managing the big guns. Simple as these facts are, I can hardly insist too strongly on this, that the whole use or abuse of each of the three arms turns on the original cause of the subdivision of armies into them. The question always is, how best to bring out the full effectiveness of the *weapons* of the infantry and of the artillery, and the horses of the cavalry.

There are two somewhat curious facts which, so far as I am aware, have not been pointed out before. Hardly any recent period of war, however long, appears to have developed during its course a great improvement in armament which has been so perfected as to be successful during that war. Scarcely any one of the great European wars of this century has commenced without some improvement upon the material of war which has been effected during the preceding interval of peace. Thus, percussion caps were introduced shortly before the Italian war of 1848. Rifled small-arms had come into effective use just before the Crimean war. Rifled ordnance was used freely by the French in the campaign in Italy in 1859. The campaign in which Austria and Prussia crushed Denmark cannot fairly be reckoned among these. It was in fact the trial ground for the breech-loader, which came into effective use on the Prussian side in 1866. Lastly, in 1870 we have the mitrailleuse.

In all these campaigns except the last the superior armament was on the side of the victors. It must be carefully borne in mind in reading of any campaign, that these questions of armament are always of extreme importance. They are constantly ignored even by regular military historians, except where a traditional interest has in some way attached itself to a special case. I may cite, as a notable instance of this, that though, as I have said above, percussion caps had been invented some time before the war of 1848, I have been entirely unable to find any record as to whether they were used on either side, or on neither, during the campaign. Yet, military criticism, without a knowledge of such points as these, is entirely unsatisfactory. True deductions may, no doubt, often be drawn from the bare outline of events; but the general who feels that he possesses a practical certainty of success in small details, finds this fact tell in his favour to an extent which enables him to venture many things which it would be very rash to attempt under less favourable conditions. The fact that the particular improvement of any given period has ceased to be the one that we now adopt, by no means proves that it was not of almost decisive importance at the time when it was introduced. Thus Frederick the Great of Prussia was much assisted in his victories by a substitution made in his day of iron for wooden ramrods. The wooden ramrods broke, and were at best so much more clumsy in loading that his men were able to fire much more rapidly than their enemies. Such inventions as these always in two ways increase the power of an army. It is not merely that they have a greater physical effect. They give a confidence to one side, and discourage the other so much, that after a victory or two won by their aid, men come to believe on both sides that those who possess the superior weapon cannot be beaten. Then they certainly are not likely to be so.

To attempt, therefore, to study the motives of a general's action, and either to judge his conduct or to learn from it without ascertaining all that can be found out under this head, is certainly misleading; the more so because we are all apt to fancy that success is in each particular instance a sure proof that skill has been displayed by the successful; a conclusion scarcely more sound than the deduction that a man is a good whist-player because he has won a rubber, or a bad one because he has lost it. To carry the illustration further, a good whist-player may sometimes calculate too much on the chances of a very strong hand. He is mistaken, but his play may have been correct. So the assumption that a general, with certain special advantages in his favour, such as those I have described, has been wrong because he has attempted what under other circumstances would have been rash, and has failed, is certainly not a fair one. What, moreover, is more important is, that the deductions so drawn are apt not to be just, and to lead men to neglect the qualifications which are always necessary in the application of general principles.

It is in the infantry that the successive changes of armament have produced on the whole the most important revolution. It will be necessary to observe how these have gradually affected the drill when we consider that subject; at present we must note the manner in which these changes have tended to modify the qualities which are of the greatest practical value in a soldier. As long as it was possible to fight out battles hand to hand, a certain fiery dash and eagerness to close was all important. But as the deadliness of fire was more and more appreciated, and generals began to perceive that it was possible to rely upon it more and more, provided it were brought to bear with proper effect, a change came over this part of the question also. It was found even in the Peninsula that what told with the greatest effect was a calm readiness to wait in obedience to orders till the moment had arrived when the powers of the weapon could be brought to bear with the deadliest result. One of the ablest of the generals opposed to us in Spain (Marshal Bugeaud) has given a most lively and generous description of the manner in which a fight in those days between his own troops and ours used to take place. The following may serve as an epitome of his account, the French being, he says, almost always the assailants:—The attacking columns move to assault the position held by the English just beyond the crest of some gently rising hill. The English, either at first lying down or standing with the butt-ends of their rifles on the ground, give no sign of their existence, except a line of motionless red, which just shows and no more along the crest, while behind it here and there an officer is seen riding quietly up and down. At first the French dash forward with furious courage, chattering a good deal, abusing the English most savagely. The excitement increases from moment to moment. One after another cannot be restrained from breaking the ranks, that he may relieve his feelings by a shot at the enemy. The column becomes more and more confused. As they get further and further up the hill the excitement and hurry tell more and more: the pace cannot be kept up. They realise ever more and more unpleasantly the fact that all their excitement and flurry have produced no effect upon the red line above them. These feelings have full time to react upon the previous over-excitement. At last an unpleasant chill succeeds, and now they are within point-blank range of the enemy. They hear a single cool word of command repeated all along the English line. Down come all the muskets towards them. A moment more. Then comes a volley of which few shots go astray. The smoke clears away. Moving straight down towards them they see a line of bayonets. Then a loud cheer rings out from the hitherto silent ranks. These are coming on now steadily, rapidly—with an evident intention not to stop—straight at them. The strain is too severe. The column does not wait to be attacked, but breaks and flies. "Never," says the old marshal, "did I see other than one end to it."

The description tells more than a hundred dissertations on the theory of the thing in what way in those days the weapons could be made to produce the greatest effect. The fire of modern small-arms has become so infinitely more deadly, its range and its rapidity of fire are so very much greater, that many new considerations have to be taken into account. But of one fact we may be perfectly sure, that no application of modern weapons can be effective which is not based upon the same thorough appreciation of the fact that men are not machines, that the effect you produce is not in mere proportion to the number you knock over, as if they were pawns or ninepins; but upon the extent to which you also work upon their imagination and spirit. It would be difficult from the recent campaigns to obtain an illustration as telling; a fact for which it would be easy to account without assuming that anything has occurred to modify the importance of such considerations. General Grant, however, now President of the United States, used to say, "When you see that your men are pretty nearly exhausted and are beginning to waver, then is the moment to close; for depend upon it your enemy is nearly in the same condition." I insist upon this for these reasons. Beyond all question the fire of modern weapons has become so deadly that our attention has now to be directed, and perhaps it is not unfair to say directed mainly, to the object of diminishing the effect of the enemy's fire, at the same time that we endeavour to make our own as effective as possible. But for all that, there is no sign whatever that the following statements are less true than they were formerly: that the critical moments of battles arrive when men's minds have reached a certain point of tension; that the weapons will be used with the greatest effect by him who succeeds in making them tell most heavily, both in producing that state of tension in the enemy, and in over-straining it; and that tactical skill will now, as formerly, consist very largely in appreciating correctly when the moment has arrived when decisive action will break down the nerve—the resisting energy—of the opposing forces, and in constantly feeling, as it were, the moral pulse of the forces to be led to victory. Of course, I am not here speaking of the combinations by which preparation is made for success. Those are strictly "tactical" questions with which these papers are not concerned. I speak here only of the direct application of the weapon, as a necessary introduction to certain matters of training which depend on it, and for the moment only of the infantry weapon.

Now it will be observed that in the description given by Marshal Bugeaud, the difference in effect of the irregular isolated shots sent by occasional Frenchmen against the English line, and the single volley all poured in at one time, is very striking. It is impossible to doubt the difference in effect produced by a great loss suddenly inflicted, from that caused by the same loss due to a long continuance of apparently not very effective fire. In the one case the assailants see and feel all round them the loss their numbers have sustained. Their adversaries seem to them not to have attempted to oppose till the opposition began to be most effectual. Hence, the assailants have no previous consciousness of success to carry them on. The defendants have no consciousness that their assailants have been gaining on them, but only that they have been allowed to pass over without opposition space where the fire would not have been effective. On the other hand, if the defending force had fired irregularly at the assailants, that irregular fire at considerable distances would not have produced any decisive loss. The assailants would have gained confidence by their successful advance despite of it. The obvious inefficacy of their own fire to stop the attack would have proportionally cowed the defendants.

Such are the arguments by which the superior efficacy of volley-firing and "reserved" fire have been upheld. To these it must be added, moreover, that the number of men you can trust to fire calmly and leisurely, taking proper aim, is not so great even in the best trained army as might be supposed; that in a volley this can be attended to sufficiently by the officers simply looking along the line. Nevertheless, we are assured by the best authorities that in practice, as soon as a battle has begun, separate firing is the rule and not the exception. It is not a little notable that the nation which is supposed, and rightly supposed, to have developed more than any other the individuality of the soldier, has especially endeavoured in its preparation for war to retain the advantages of the system of volley-firing, and to combine them with those of the free action of the individual. Even in that special form of fighting, the development of which has been due to the nature of the new weapon—skirmishing—the Prussians in their training exercises always move up small bodies of men in support of any particular part of the scattered skirmishers who may require assistance, and make them fire volleys till the opposition is overcome.

Nor is this advantage of the sudden telling effect of a greater mass of fire poured in at one time the only one which is obtained by having the men kept together as long as possible, and brought together again as soon as may be. For under the awful excitement in which men find themselves in the stress of battle, it often seems to turn on a hair whether the very violence of the feeling will lead them to go on in confident and victorious advance, or to fly in ruinous disorder. Then nothing so restores their spirit and gives them energy for fresh struggles as to find themselves among their companions, standing in the place they are accustomed to. Losses then seem less terrible than when each man by himself can let his own imagination run wild, and when the fearful sounds on all sides leave an impression far above the reality of danger. It is necessary to state all these modifying circumstances first, in order that their effect may not be ignored; but the fact which remains of the most importance in the latest phase of war is, that in order to get the full value out of the weapon, it is absolutely indispensable to increase the latitude which is allowed to the individual soldier in his use of it. At the same time the space which must be covered by a given number of troops must be very much greater than it was formerly, in order that the enemy's fire may not cause the awful destruction which would be produced in densely crowded ranks. The possibility of a charge with the bayonet under almost any conditions is now a matter of grave dispute, and as a result from all the conditions above enumerated, it may be pretty safely asserted that the general manner in which the infantry weapon will be employed in future will be somewhat of this kind. In attack, when moving over open ground, men will advance as rapidly as possible, and in as scattered an order as may be. Where isolated cover presents itself sufficient for individual men, there it will be taken advantage of, in order to enable the advancing assailants to bring fire upon the defendants. Here the rapid manner in which the new weapon can be loaded will tell so far as the point goes in favour of the attack; for formerly it was scarcely possible to employ the small-arm with effect in advances at all. The delay occasioned by desultory firing was too great in proportion to the advantage gained by it. Now, thanks partly to the rapidity of fire, partly to the new method of advance in deep "clouds of skirmishers," some will be always firing whilst others are advancing. But always when possible knots will be formed under the orders of officers or non-commissioned officers as often as cover can be obtained for them. These will then, if possible, from their new position bring an effective volley-fire to bear on the defendants, and as soon as opportunity offers they will again scatter in order to advance. Finally, the attack will be decided by a gradual accumulation of troops so near to the point to be attacked that the fire of the defendants is completely overpowered, and entry forced into the position with comparatively little opposition. Always, however, the great danger will be lest too great a mass should accumulate at any one spot. The advantage of numbers must be sought rather in obtaining a vast number of points from which fire can be brought to bear, and in extending over a great expanse of ground, in order to try every part of the line of defence, and find its weak point, than in mere accumulation of weight, and an imposing body for the final rush.

On the other hand, it is idle to deny the direct advantages which man for man, and at the point where the attack occurs the defence has gained by the development of the effectiveness of fire. Since during the time that a man is moving forward he cannot be shooting, it follows at once that the man who is shooting from a fixed position gains in proportion to the effectiveness of the fire which can be delivered during the time taken by his assailants to move over the ground. So great is the advantage which, from this cause, the new weapon confers on the defendant, that were it not for two considerations it might almost be considered decisive. The first is, that in the best situation which can be selected for taking up a defensive position there is always some point which is weaker than the rest, more exposed, that is, to the assailants' fire, and the access to which is less under the fire of the defendant; and that while the defendant necessarily has to be prepared for attack at every point, the assailant is able to gather his forces against the point which he selects as the most vulnerable. The other is the enormous power of modern artillery, which enables an assailant to bring against the position he assails an overpowering fire long before his infantry are ready to move to the assault. This leads us naturally to the next consideration in regard to armament—that which relates to the big guns. There are some further points in the question of attack and defence which are connected with the effective employment of the infantry arms, but they are much more easily understood when we consider them with reference to the "drill" which has been devised in order to enable armies to take advantage of the power of their weapons, that I shall leave them until this part of the subject is brought under consideration.

TECHNICAL DRAWING.—LXIV.

DRAWING FOR BRICKLAYERS.

FIG. 525.—The design of the floor given in this example is of a very simple character, and consists of octagonal and square floor-tiles. Tiles of this character, and of varied manufacture, are now made by several firms in this country, and may be had to suit any building, or adapted to any sized floor. Numerous beautiful specimens of these may be seen in the South Kensington Museum. To draw this pattern, divide the whole width into three equal parts, and draw lines dividing the surface into three equal strips, or as many as may be required in the design. Next draw lines at right angles to these, thus dividing the whole surface into squares.

In one of these, as A B, draw diagonals, and from the angles, with a radius extending from the angle to the centre (C), describe arcs cutting the sides of the square in D, E, F, G, H, I, J, K. Join E H, I K, J G, and F D, and an octagon will be inscribed in the square, as shown in Fig. 525, or on a larger scale in Fig. 526. Now measure the distance from the angle of the square to I or K, and set off the length on each of the four lines meeting at the angles of all the squares Join these points; the design will then be completed, and may be coloured according to taste. The squares may be formed of four triangular pieces, or may consist of complete squares.

In the following study (Fig. 527) another design for a tiled floor is given, the forms of the tiles being hexagonal and lozenge. In order to guide the student in drawing this pattern, the annexed elementary figure (Fig. 528) is given, from which the precise construction will be seen.

Draw the regular hexagon A B C D E F. Divide each of the sides into three equal parts, as G, H; I, J, etc.

From the various points draw lines across the hexagon, parallel to the respective sides. These intersecting, as at K, L, M, will give a smaller hexagon in each angle of the original figure, leaving the star in the middle, and a triangle, as G H M and I K J, in each of the sides. These triangles are the halves of the lozenges of six surrounding stars.

Fig. 527.—In commencing this pattern, draw the hexagon A B C D E F, and adjoining it construct the others, which are to contain the smaller hexagons. Finish each in the manner shown on the previous figure, and colour according to taste.

FREEHAND DRAWING.

It has in all the previous lessons been urged on artisans, to whatever branch of industry they may belong, that *all* drawing cannot be executed by the aid of instruments, and that it is therefore indispensable that they should acquire some power in drawing by freehand, guided only by the eye. The question

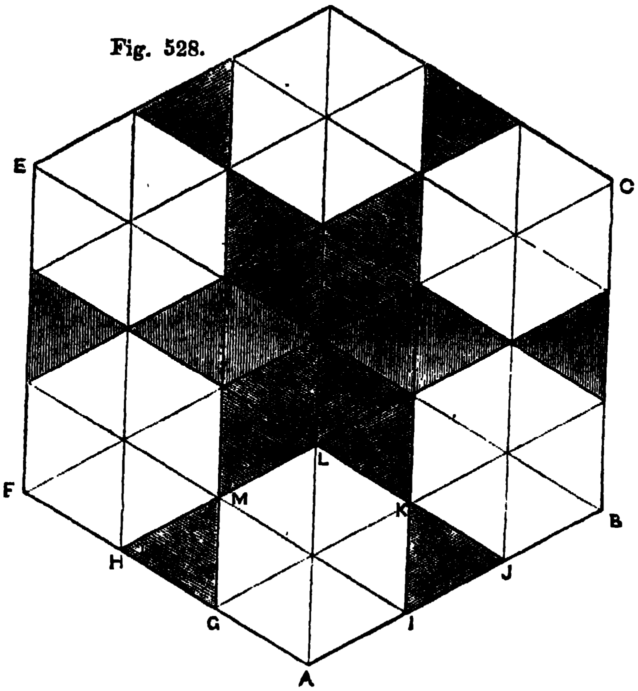


Fig. 528.

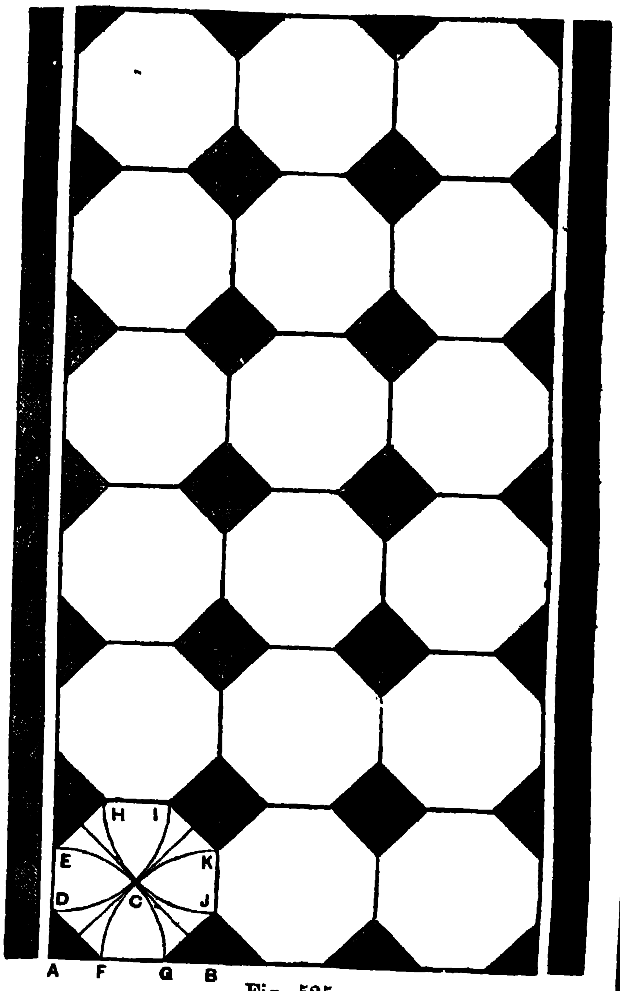


Fig. 525.

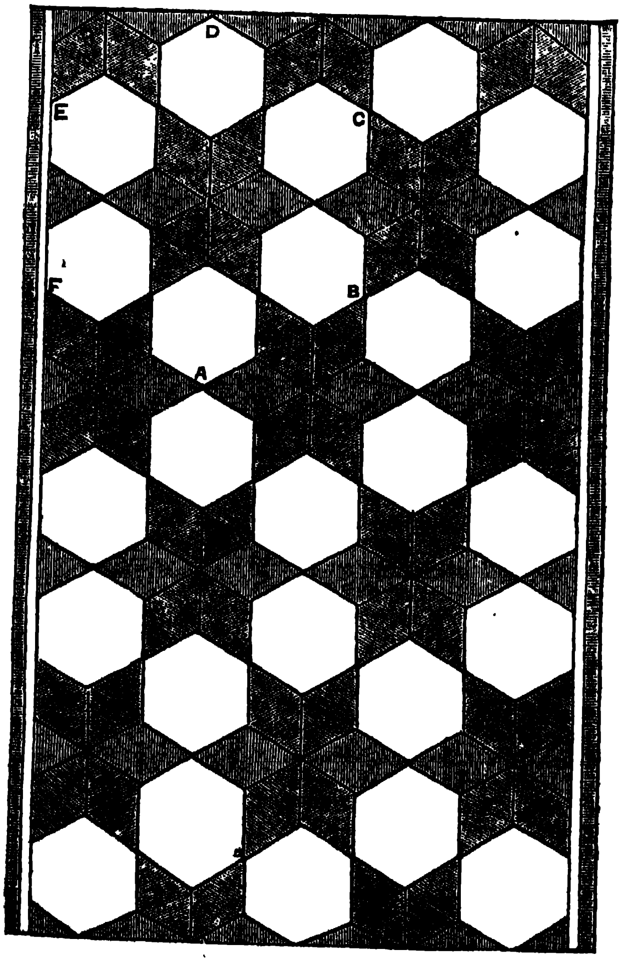


Fig. 527.

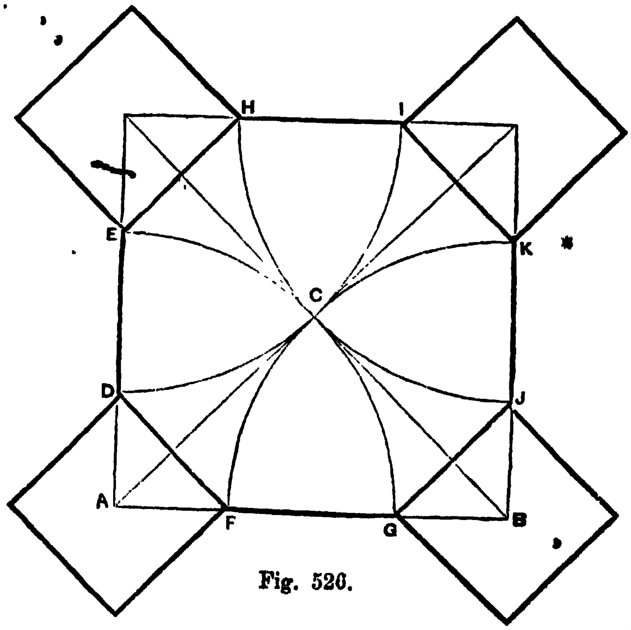


Fig. 526.

should not be asked, "Does a bricklayer ever require freehand drawing?" for although education should as far as possible be thoroughly practical in its character, still it is unwise for the young to study in such a narrow track. A bricklayer may not absolutely require freehand drawing in his work; but, for all that, the contemplation of graceful and beautiful forms refines and elevates his taste; and the accuracy of perception obtained by the practice of drawing rigid forms is such that it frequently enables him to check the work done by means of instruments, and to detect where an error has been made. Besides this, a bricklayer need not always draw bricks only; he will in time draw buildings, with their decorations; he will, by the aid of a knowledge of object drawing, be able to make sketches of any building or place he may visit; so that, from every point of view, the student is urged to follow the elementary course here laid down as a stepping-stone to higher subjects.

In order to avoid repetition in these lessons, and to economise space, the subjects of the freehand exercises in "Drawing for Stonemasons" may be used at this stage; they will be found at page 265, Vol. II., of THE TECHNICAL EDUCATOR.

Assuming then that these have been satisfactorily accomplished, we proceed with

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

FOUNDATION OF BUILDINGS IN GOOD SOIL.

The meaning of the term and the general principles of foundations have been treated of in lessons on "Building Construction." The subject is here continued in order to give the student a further insight into it.

The ground on which a building is to be erected should be carefully examined to a considerable depth, and if it proves to be good throughout, such as rock, gravel, or soil of a sound, uniform quality, not liable to be altered from time to time, either entirely or in part, by the effects of water acting below the surface, a trench is cut all round, and carefully levelled; in this the walls are commenced, giving, however, to each wall a base somewhat thicker than that part of it which is to appear above ground.

If the ground to be built on should happen to be very irregular, such as the side of a hill, which often occurs in practice, instead of cutting the whole trench intended for the building to one general horizontal level, it is usually cut to several levels in steps or terraces, or, as it is technically termed, "benched out." When a building is to be erected, the ground should not on any account be cut to an inclined plane, although this method is sometimes used in low boundary walls, as in the north enclosure of the infantry barracks at Chatham, where the courses of bricks are all laid sloping. In any other description of wall this arrangement would be perfectly inadmissible.

PHOTOGRAPHY.—VIII.

By J. C. LEAKE.

DRY PLATE PROCESSES.

ALTHOUGH for excellence and certainty of result the wet collodion process already described is unrivalled, yet the difficulty and inconvenience of at all times carrying the necessary chemicals and a portable dark room to the scene to be photographed, are such that a process by which plates capable of receiving an impression, and which can be prepared and developed at home, has always been a desideratum to the out-door worker. Much attention has been given to the production of sensitive dry plates, and at length several processes have been invented, which are as nearly as may be expected equal to that upon wet collodion, although the same amount of sensitiveness or certainty cannot be at all times secured. Enough, however, has been done to render these processes exceedingly useful where the subject will allow of a moderately long exposure; and in some cases, such as dimly lighted interiors, where the exposure would be too long for the proper keeping of wet plates, those prepared as we are about to describe will enable the operator to obtain pictures which it would be impossible to produce by any other method.

There are, as we have before remarked, various processes by which sensitive dry plates may be prepared, but their number may be reduced to two or three for practical purposes, the others being for the most part merely modifications. Of these standard processes, that known as the collodio-albumen stands first, both as regards delicacy and certainty, as well as for its extraordinary keeping properties. As may be implied from its title, this is a combination of the albumen and collodion processes, both of these substances playing an important part in the production of the picture. For the production of sensitive plates by this process two nitrate-of-silver baths will be required; and we may here remark that as a rule the silver baths required for exciting the collodion film in dry-plate work should never be of less strength than forty grains to the ounce of water, and should be kept slightly acidulated with acetic acid.

It is also advisable to keep separate bath solutions for wet and dry plate work, as the conditions required are mostly different; attention to this point will save much trouble and vexation. For exciting the collodion film a bath should be mixed containing forty grains of nitrate of silver to the ounce of distilled water. To each pint of this solution add two or three grains of iodide of potassium and enough acetic acid to freely redden litmus paper. The second nitrate bath which will be required for exciting the albumen must be prepared as follows: nitrate of silver, thirty grains; distilled water, one ounce; dissolve and add one ounce of glacial acetic acid to each pint of solution. These baths must be kept each for its own purpose, or failure will result. Next prepare the following solution: distilled water, one and a half ounce; pure albumen (from fresh eggs), five ounces; iodide of potassium, twenty grains; bromide of ammonium, five grains. Dissolve the salts in the water, and add to the albumen in a large bottle, as before described for the preparation of albumenised paper; and after a few minutes' shaking add from forty to fifty drops of strong liquor-ammoniæ; again agitate until the whole becomes converted into froth, after which it should be allowed some hours to settle. It must always be carefully filtered before use. With these solutions prepared we may pass on to the manipulative details.

Any good bromo-iodised collodion will answer, but a sample should be selected which adheres well to the glass, and it should be remembered that a highly-bromised collodion will be most successful in all dry processes. After coating allow the film to become well set before immersion in the nitrate solution, and allow at least four or five minutes for the conversion of the iodide contained in the film. When removed from the nitrate bath, wash the film well first with distilled and afterwards with common water, in order to remove the whole of the free nitrate of silver. Pour into a flat dish, which must be scrupulously clean, enough of the following solution to amply cover the plate: iodide of potassium, three grains; water, one ounce; and allow the plate to remain in this four or five minutes, or while a second plate is in course of preparation. Wash well with clean water, drain, and pour over a portion of the iodised albumen, allowing it to soak well into the film. Allow the first quantity of albumen to flow off the plate into the sink, and repeat the operation with a fresh supply of solution, reserving the surplus for the first coating of the next plate. Set the coated plate to drain upon blotting-paper. It is a good plan to provide a clean box or cupboard in which the plates may be set to dry, as the albumen is exceedingly liable to attract particles of dust, which would produce spots in the finished picture. When the plate is dry (and it may be dried by artificial means if required, being in its present condition nearly, if not quite, insensitive to light), it will be ready for immersion in the second nitrate-of-silver bath. Before this immersion, however, it is better to thoroughly dry the film before a fire, making the plate quite hot, or blisters will probably ensue, and the film may be broken. After immersion in the second bath for one or two minutes the plate should be removed, again thoroughly washed in clean water and dried, when it will be ready for exposure in the camera. Respecting the exposure little advice can be given, except that as a rule plates prepared as above described will require at least four times that necessary for wet collodion, and frequently even more. One of the great faults of inexperienced dry-plate workers is that they frequently under-expose their pictures. Over-exposure can mostly be remedied in the development, but nothing can possibly be done with a plate if the detail in the darker portions be not properly impressed.

The usual developer for plates prepared as above described is composed of a saturated solution of gallic acid, made by pouring boiling water upon the crystal and agitating, pouring off the solution when cold. A quantity of this solution should be prepared and filtered, and a small proportion of a ten-grain solution of nitrate of silver added before pouring over the plate, which should previously be wetted, in order to facilitate the flowing over the surface.

In the case of small plates, a sufficient quantity of the developing solution may be poured into a dish and the plate immersed, but care will be required in order to avoid stains, if the solution be not kept in motion, and as soon as any discolouration of the solution is observed the plate should be well washed and a fresh quantity applied. To those accustomed to the rapid development of collodion negatives the process in the case of dry plates may seem long and tedious, a collodio-albumen plate seldom developing in the way we have just described under half an hour. Care must be taken, however, not to make the negative too intense, as the deposit in this case is of a peculiar yellow non-actinic colour, so that a negative which appears to the eye thin and translucent is chemically sufficiently dense to yield a vigorous proof, while if the density were carried to anything like that usually necessary in a wet collodion negative the print would be hard and utterly useless. In case of under-exposure, or if the development should be unusually tardy, it may be hastened or completed by the use of a solution of pyrogallic acid, as follows: pyrogallic acid, two grains; water, one ounce; glacial acetic acid, twenty minims. This solution must be poured on and off the plate, and not used in a dish, as its action is extremely rapid, and must be carefully watched. Of course the usual addition of a few drops of nitrate-of-silver solution must be made before applying it to the plate. Sometimes the development is effected by means of pyrogallic acid solution entirely, and this is the modern practice, but it is not so safe in the hands of the tyro as the slower method by means of gallic acid; and we would therefore suggest that its use be deferred until the operator has gained some experience in the development of dry plates. When the operation of development is completed the plate may be washed, and fixed in a saturated solution of hyposulphite of soda as usual. The process we have now described is one which may be easily and safely worked, and although there are others which are more rapid and perhaps more simple, it is the one which the beginner should always commence with, as being likely to produce less failure and disappointment than those of a more delicate character, such as we shall describe in our next paper.

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SANITARY ENGINEERING.—XVIII.

CISTERNS AND ECONOMY OF WATER—VENTILATION OF PIPES.

In two preceding papers (XVI. and XVII.) we briefly dealt with the methods of water-supply for villages and towns; and we now proceed to give the detail of various inventions for storing and also for economising the supply thus obtained. In the last century cisterns were almost invariably made of lead, in some cases cast solid of sufficient thickness to be fixed without external casing; the outside was often decorated with panelling in designs, and sometimes with coats of arms. The usual mode, however, was to provide a strong wooden cistern, which was subsequently lined with lead soldered together at the angles, either cast in sheets or rolled in a mill, described in the first case as "cast," and in the latter as "milled" lead; and this latter system is still extensively in use.

Within the present century, however, several other materials have been adopted for the purpose—*e.g.*, cast iron in one piece for small cisterns, and in a number of plates jointed together with flanges and bolts for those of larger dimensions, the joints being rendered water-tight with cement. Examples of this class of construction may be seen in the water-tanks for the supply of the engines at most railway stations.

The introduction of slate is, however, the most important feature of modern times in the construction of what may be termed household cisterns, and as it is much cheaper than lead, it has almost entirely superseded its use for all common purposes. The increased facility in obtaining what is called slab slate of late years, renders it possible for all, except very large cisterns, to be constructed with the ends, sides, and bottom each consisting of one single piece of slate. These are rabbeted together at the angles, confined in their place if necessary by small iron bolts, and the joints rendered water-tight with red lead. As slate, from the density of its texture, is scarcely affected by atmospheric changes, when the work is once properly executed, these cisterns are perfectly efficient. They are also free from an objection that applies to lead of all descriptions, and that is, that especially with soft water, when the water remains for any considerable time in contact with the lead, a chemical action takes place by which the water holds a certain quantity of lead in solution; and if this be allowed to proceed to any extent, the result when the water is used for drinking is very deleterious, producing the symptoms which are well recognised as those of lead poisoning.

Another material recently introduced for this purpose is sheet iron, which should always be galvanised to protect it from rust. The sheets are riveted together, and, where the size is so large as to require it, strengthened with iron cross-braces. This material is largely used for ships' tanks, as well as for household cisterns, and most of the large workhouse infirmaries erected recently, and also the large groups of buildings carried out within the last two or three years for the Metropolitan Asylums' Board, have been provided with cisterns of this construction.

Where, however, as is often the case in country houses, the general storage for the water is below the level of the ground, a brick tank is the usual receptacle. This can be made perfectly water-tight by a lining of cement within, and when the size is unusually large and the depth considerable, an outside coating of asphalte may be employed with advantage.

Having thus described the materials for the construction of cisterns in ordinary use, we now give the detail of various contrivances for economising the water-supply.

In districts where the supply is limited, or in houses where the cistern accommodation is comparatively small, it becomes important that the requisite flushing should be done with the minimum quantity of water, and for this purpose various inventions have been introduced. The one shown in Fig. 10 is Hooker's pattern, divided into a smaller and larger compartment, with levers and valves so arranged that the contents of the smaller cistern only are discharged for flushing purposes; the same action that releases the water closing for the time the connection between the two, which is restored when the operation is complete; the main store being thus retained intact, and the smaller portion refilling itself immediately.

Our second illustration (Fig. 11) shows a flushing cistern of somewhat similar construction, but so arranged as to be independent in itself, and to be attached to any ordinary larger cistern already fixed or otherwise, the same object being attained.

Our third sketch (Fig. 12) shows another adaptation of the same principle, but with a horizontal instead of a vertical division, the whole construction in this case being of cast iron.

In a previous paper we have had occasion to call attention to the difference between "constant" and "intermittent" supply, and our next illustration (Fig. 13) shows a contrivance for the economical supply of water to a closet where there is a *constant* supply at a considerable pressure, for which purpose only it is adapted. The air-chamber, which is of cast iron, must be connected with the main, and perfectly air-tight. The weight of the head of water compresses the air within the chamber, and fills it with water up to a certain point, the quantity being sufficient for the thorough service of the closet. When the closet is used the connection with the air-chamber is opened, the compressed air regains its original volume, discharging the water forced in by the pressure, the same action severing the connection with the main, which by the return action is again opened, when the air-chamber again charges itself as before; about two minutes being the time required, or even less.

This apparatus, which is called Common's patent high-pressure closet, has been used extensively and successfully in Brighton and other large towns where the constant supply is in operation. In a subsequent paper of this series we propose going in fuller detail into the various descriptions of closet apparatus, and therefore omit at this point any description of the remaining portion of the sketch, which is only introduced as an illustration of a certain class of methods for economising water-supply.

Regulators, of which Howard's patent is perhaps the best of its class, are another means of attaining the same object. They are attached to the water-service at its junction with the apparatus, and not to the cistern, and consist of a brass valve so arranged that the delivery of the water can be regulated by a screw at pleasure, in accordance with the head or body of water to be dealt with. The rush consequent upon the working of the ordinary closet is thus avoided, sufficient water only being delivered to do the work thoroughly without waste. When the water, however, is charged with any foreign matter, the small aperture in the valve is apt to clog, and thus its efficiency is interfered with. In these cases Underhay's system may be adopted with advantage. Here the supply of water is received into a valve constructed with leather, like a bellows, the same result as before—a gradual discharge—being obtained; the leather, however, is perishable, especially if it be exposed to damp externally.

Having thus briefly described some of the methods in ordinary use for economy in the use of water-supply in connection with drainage, before going further into the detail of valves and closets, which will form the subject of our next paper, we wish to call especial attention to a matter we venture to think not generally understood, and that is the ventilation of pipes.

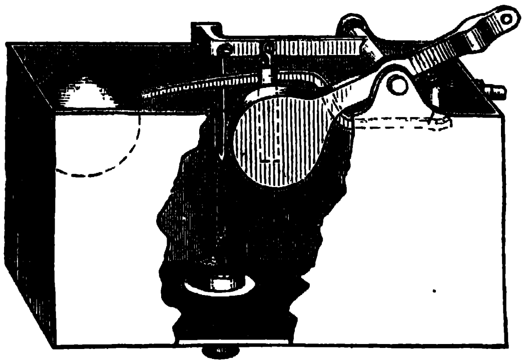


Fig. 11.

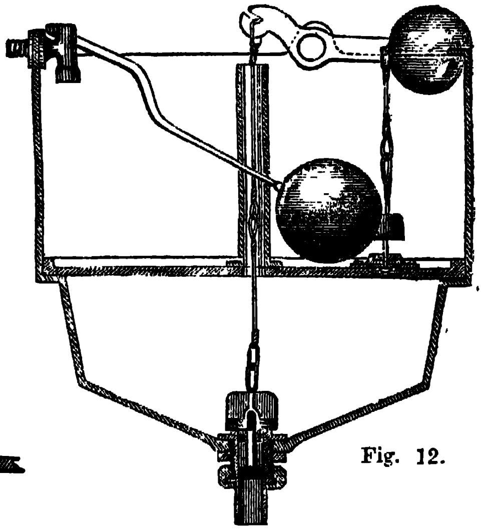


Fig. 12.

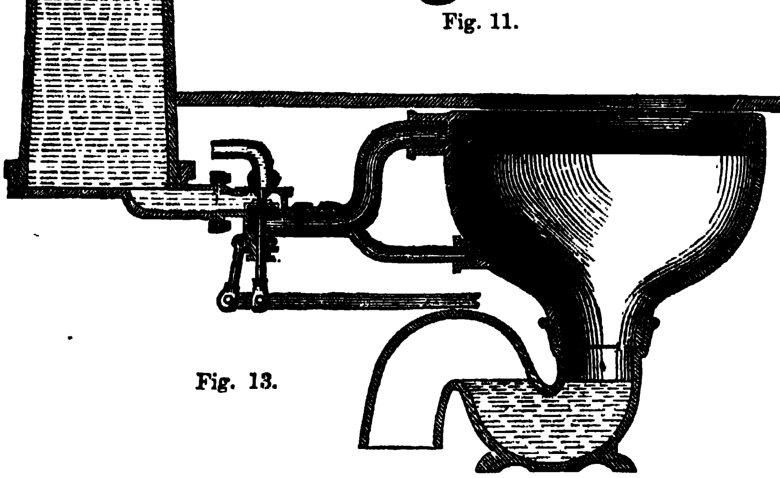


Fig. 13.

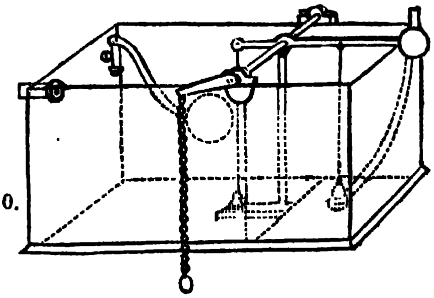


Fig. 10.

Lead is still the material generally in use, and will probably continue so to be; but whether of lead or of iron, or of any other material, our remarks will equally apply. One of the most important sanitary requisites in buildings of any kind is good plumbers' work; and there are two all-important requirements. The first is, that the strength of the material shall be sufficient, and the work well executed, as in no trade is perfection of workmanship more absolutely necessary, the least defect revealing its presence by its unpleasant and unhealthy consequences. But the second is equally important, and that is ventilation, as we shall proceed to explain, for the work may be perfectly well executed, and yet if this second requirement be either neglected or misunderstood, unsatisfactory results ensue, the cause of which is often obscure and difficult to trace. The great secret is to provide for the escape of all foul vapours to the outside air by means of the pipes themselves. Ordinary building specifications, as drawn even by the best professional men, are often wanting in explicit detail in this respect. The common wording is, "provide all necessary air-pipes," the details being too often left to the discretion of the working man. Every soil-pipe should have a ventilating-pipe from its topmost point, communicating with the external air, of not less than two inches in diameter, and then the pipe itself becomes as it were the flue by which the remainder of the system with which it is connected is ventilated; and in some cases this is so completely carried out, where unusual care is required, that the space between the bottom of the valve and the water in an ordinary valve-closet has a small air-pipe running into the ventilating soil-pipes. We may mention Sandringham House as an instance of the adoption of this precaution. The next point is to prevent any foul air from becoming what is technically called *water-bound*, *i.e.*, that when flushing takes place, a free escape should be provided for the air displaced, which, unless this is done, bubbles up through the water by which it is supposed to be hermetically confined, with the usual unpleasant results; and sometimes even when the plumbers' work is perfect in itself, a want of attention to this same point of water-bound air in the drains will produce the same result. Objections are frequently made to erecting closets in confined situations from fear of the want of general ventilation; but if the above cautions are carefully attended to by an expert, they ought to be absolutely and perfectly free from smell in whatever position they are placed.

This question of ventilation is all important in matters connected with drainage. Miss Nightingale says, "I have met just as strong a stream of sewer air coming up the staircase of a London house as I ever met with at Scutari, and this sewer air is retained in the bedrooms. No house with an imperfectly trapped pipe communicating with the sewer from the sink, can ever be healthy, and may at any time spread a fever among the inmates of a palace." The recent (1871-2) illness of the Prince of Wales has given only too striking confirmation to this well-founded observation. In our present paper we have given, as far as our limits have allowed, some guidance as to the general principles to be adopted for the complete avoidance of all danger as far as internal construction is concerned; and as we proceed with the subject, we hope in some subsequent paper to show how by the proper trapping of drains external to the house, with ventilation always kept in view, the evils which we fear are only too common may be effectually guarded against, and the noxious gases evolved from sewerage harmlessly discharged into the external air, and typhoid fever, with its cognate disorders, effectually kept at bay.

MINING AND QUARRYING.—XXI.

BY GEORGE GLADSTONE, F.C.S.

COPPER (*continued*).

PROPERTIES — ROLLING — HAMMERING — WIRE-DRAWING — PLATING—ALLOYS—SALTS OF COPPER.

PURE copper is easily recognised by its red colour, which is so familiarly known as not to need description; there is, indeed, no other simple metal with which it can be confounded. It is capable of receiving a high polish, but does not retain its brilliancy long, as it is liable to be affected by the atmosphere, under the influence of which it turns green, or a dark brown. This circumstance detracts considerably from its utility, except when combined with other metals which reduce its liability to tarnish. It melts at about 2000° Fahrenheit. It expands but slowly under the influence of heat; the calculation being that its linear expansion between the temperature of ice and that of boiling water amounts to $\frac{1}{582}$. Its power of conducting heat is, however, about 2½ times that of iron. Its elasticity is only slight; but it is very tenacious, and can therefore be rolled or hammered out into thin sheets, or drawn into fine wire; and it becomes harder under these processes.

On account of its high value, it is never used in an unmixed state for large works; but it is applied to a great variety of purposes, in which its special advantages outweigh the question of cost. Some of these must now be briefly alluded to.

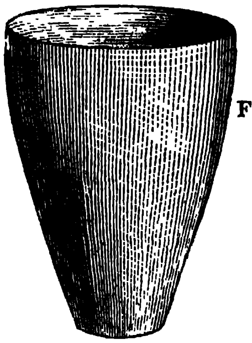


Fig. 1.

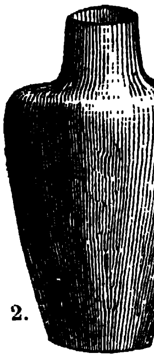


Fig. 2.

The bottoms of ships are sheathed with copper, or an alloy of this metal, for the purpose of protecting them from the attacks of worms, which would otherwise bore holes in the wood; as well as from barnacles, which would attach themselves to the surface. The former would impair the strength of the vessel, and cause her to leak; the latter would interfere with her sailing powers by preventing the free passage of the hull through the water. The gentle corrosion of the copper caused by the sea-water prevents any of these creatures from adhering to it. In making the sheathing the metal is rolled out into large sheets between heavy cylinders driven by steam. The cakes of copper while red-hot are passed between the first pair of rolls, and are then re-heated before the second rolling, and so on, until the plate has acquired the thinness desired; each successive pair of rolls being set closer together than the preceding. During these successive heatings the copper becomes oxidised on the surface; to free it from which it is dipped into a bath of urine, then heated afresh, and while hot plunged into a tank of cold water. The ammoniacal salts, having entered into combination with the oxide, form a scale, which is detached by the water, leaving the surface of the metal quite bright.

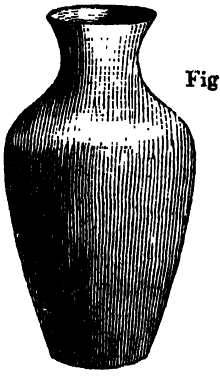


Fig. 3.

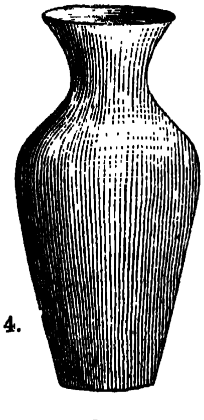


Fig. 4.

Copper sheets, thinner than those used for marine purposes, are sometimes employed in roofing. The spires and roofs of old churches and other public buildings are not unfrequently to be seen coated with copper, which may be recognised by its dull greenish hue; but this application is passing out of date, as lead, zinc, and tinned or galvanised iron are found to be more economical.

Many vessels used for culinary and manufacturing purposes —such as moulds and stewpans, urns and kettles, stills and coppers—are made of hammered metal. For making such articles a circular sheet of copper of the required diameter and thickness is taken, and beaten on one side until it assumes a hollow conical form; and by continuing the hammering on the inner side it can be beaten out to almost any shape that may be desired. From time to time the metal has to be warmed or annealed in order to prevent its becoming brittle; and this has to be attended to all the more carefully as the work proceeds, as the tendency to brittleness increases the longer the hammering is carried on. Figs. 1, 2, 3, 4, in the accompanying illustration, will serve to illustrate the intermediate forms assumed by a flat disc of metal under the hands of a workman in hammering it out into the shape of a vase. In this manufacture it is highly important to test the copper to see whether it contains any, or what foreign ingredients, as some of those which are commonly found in it greatly affect its malleability. Thus antimony and arsenic are highly objectionable, even when present in very small quantities; silver, on the other hand, is rather beneficial than otherwise. A careful chemical analysis should be made, as small quantities of tin, iron, and other metals besides those above named, may often be found in merchantable copper.

The tenacity of this metal renders it very suitable for wire-drawing; and this application of it may be found in almost every household, bell-wires being usually made of copper. In drawing it out, the same tendency to become hard and brittle is experienced, as when under the action of the hammer; it is, therefore, necessary to anneal it from time to time during the manufacture, in order to restore its softness and toughness. In making very fine wire the heat of a flame from burning straw is sufficient for the purpose.

Copper wire has within the last few years received other very important applications, on account of its high power as a conductor of electricity. As compared with silver wire, which is the best conductor known, and is therefore taken as the standard, it ranks as 94 to 100; none of the other metals can at all compare with those two in this respect. Only the very purest copper should be used for this purpose, as the smallest admixture of alloy or other foreign matter greatly interferes with its efficiency. In its application as telegraph wires there are several other reasons why none but the very best material should be employed; such as the immense length to which the wires extend, and the importance of rapidity of action, and of sensitiveness, in order to economise the electric power. According to the very careful experiments of Sir Charles Wheatstone, a copper wire will transmit electricity at the rate of 288,000 miles per second; but in practice nothing like this speed can be attained, as the insulators and the medium through which the wire passes become affected by induced currents, which cause a loss both of speed and power; the inferior conductors being still more liable than copper to suffer from these causes.

The same principles which suggest the use of copper wire in telegraphy also indicate the propriety of using it as a protection against thunder-storms. In shipping, where lightness as well as efficiency has to be studied, this metal is always employed. A thin strip or wire is carried up to the masthead, which by its superior conductivity will effectually protect the mast from the effects of the lightning, and that without risk of being fused by the electricity; its power of resisting fusion being in proportion to its power of conduction.

Silversmiths very frequently make use of copper as the foundation of their manufactures, and then coat the goods over with a thin film of the more valuable metal. This is done by rubbing it over with a composition made of nitrate of silver, chloride of sodium, and the acid tartrate of potash, when a decomposition of the former salt takes place, and a film of the metallic silver is deposited upon the surface of the copper. A heavier plating is made by a mechanical process. A sheet of silver is laid upon one of copper, a little powdered borax being placed between them; they are then heated in a furnace nearly to the melting-point, and while in that state are passed between heavy rollers, which bring the surfaces of the two metals into actual contact. These plates, consisting of copper on the one side and silver on the other, are then worked up into various useful articles for the table.

Copper was formerly used in making our coins of the lowest denominations, until superseded by the bronze coinage: but it also finds its way into the gold pieces, a certain per-centage of copper being mixed with the precious metal to give it increased hardness. Our standard gold contains 8·33 per cent. of copper. The red gold of jewellers is still more highly alloyed with it; sometimes to the extent of 25 per cent.

Copper forms the principal ingredient in several alloys of very considerable value for industrial purposes. The various combinations of this metal with tin have already been described in Article XVII.; while those with zinc will form the subject of the next paper. Those with nickel, lead, and other metals, will be described hereafter when treating of those different elements. Sometimes it is mixed in small quantities with iron; the addition of about 5 per cent. of copper to grey pig-iron yields an alloy of very considerable hardness, which is therefore recommended for anvils, and other implements which have to endure rough usage.

Phosphorus also forms some definite chemical combinations with copper. It yields two phosphides, the one containing six equivalents and the other three equivalents of copper to one of phosphorus; giving 14·1 and 7·5 per cent. of the latter element respectively. Both these alloys are very hard and brittle, with a crystalline structure; but if the proportion of phosphorus be reduced to about 1½ per cent., just the opposite effect is produced. This compound is much more readily fused than pure copper, becomes very limpid, and makes excellent castings when poured into chills or iron moulds. It greatly contracts in cooling, and can only be rolled and hammered when cold. It will endure a weight more than 50 per cent. greater than pure copper, without breaking; being in this respect superior even to gun-metal.

It will now only remain to consider the principal salts of copper of importance in the arts. Their uses are so varied that they will continually be found mentioned in other series of articles, such as those which treat of glass-making, colours, dyeing, alum, and many others.

The manufacture and uses of verdigris, or the basic acetate of copper, have been described under the article "Acetic Acid" ("Chemistry applied to the Arts."—XV.), to which the reader is referred. The normal acetate, $CuC_2H_3O_2$, sometimes called crystallised verdigris, is produced by taking some of the ordinary verdigris, or some of the oxide of copper, and dissolving it up in acetic acid. It can also be made by precipitating a solution of acetate of lead with sulphate of copper. The salt is poisonous; a common characteristic of all these compounds, the best antidote for which is white of egg or albumen.

The *sulphate* ($CuSO_4$ + 5 water) is more familiarly known as blue vitriol, and is very extensively used in making both blue and green pigments, as well as in electrotyping, and in medicine; it possesses highly astringent properties. The water pumped up from the bottom of copper mines often consists of a solution of this salt, but it is always charged with impurities. The commercial article is most generally made in one of the following manners. Old copper is taken and heated to redness in a reverberatory furnace, after which some sulphur is thrown in and the doors closed, when combination of the two ingredients takes place, and the metal is converted into a sulphide. On admitting the air this is again changed into a sulphate, along with some oxide. The charge is then thrown while still hot into water containing some sulphuric acid; and it is then evaporated down so as to crystallise out the sulphate of copper. It may also be made by the roasting and lixiviation of the common pyrites, the sulphide of copper and iron; but it is liable to be contaminated with a little of the sulphate of the latter metal. This, however, can readily be separated by the application of a small quantity of nitric acid. A very pure salt may also be made by boiling the oxide with dilute sulphuric acid, and then allowing the liquid to cool, when the sulphate of copper will crystallise out; or by heating metallic copper in presence of strong acid, and digesting the resulting mass with hot water, which dissolves out the sulphate of copper, from which crystals of the salt are thrown down as it cools. The former of these methods is commonly adopted in manufactories. Strong wooden tanks lined with lead are used for the purpose, and the boiling is caused by forcing steam in through a lead pipe near the bottom of the tank. From this the liquor is driven off into other leaden vessels to crystallise out, which occupies from five to six days. After being drained dry from the mother liquor, the crystals are packed in casks for sale.

The arsenite of copper, commonly called "Scheele's Green," is prepared by precipitating a copper salt, such as the foregoing, with arsenite of potassium; or with arsenious acid itself, neutralised by ammonia.

The aceto-arsenite of copper is also used as a pigment, under the name of "Schweinfurt Green." It produces a splendid colour, but it has a bad reputation on account of being a highly poisonous substance, though it is not volatilised at any ordinary temperature. It is made by taking 5 parts of verdigris or the acetate of copper, making this into a paste, and then boiling it up in an aqueous solution of arsenious acid, containing at least 4 parts of acid to 50 of water. If it should turn a yellowish-green during the process, it indicates a deficiency of acid, which must be increased, and the boiling continued for a short time longer, until the full colour has been attained.

Azurite, or the blue carbonate of copper, which has been already described when speaking of the different kinds of ores, is made into a pigment, by grinding it into a fine powder. It goes by the name of "blue verditer;" but its value in the arts is impaired to some extent by its liability to turn green on exposure to the influence of the atmosphere. It can also be made artificially. The simplest process is that of working up a quantity of chalk or carbonate of lime with a solution of nitrate of copper, when double decomposition takes place, forming nitrate of calcium and carbonate of copper. The latter settles to the bottom, and is washed with water several times till quite pure. Before the precipitate is dried, from 8 to 10 per cent. of caustic lime is added, and intimately mixed with it, when the compound acquires a beautiful blue colour, and the process is complete.

The more usual plan is to grind up a quantity of the sulphate of copper, along with a slight excess of chloride of sodium, into a fine powder, and then work them up into a paste with water. Into this small bits of thin sheet-copper, which have just been thoroughly purified from any oxide by first dipping them in acid and then washing them with pure water, are inserted; the weight of metal employed should be about equal to that of the sulphate used in making the paste. The copper is left in the paste for about three months, but in order that all parts should be equally acted upon, the whole contents of the chest are turned out and then back again about once a week. The product of this operation is carefully washed with water, and then treated with hydrochloric acid, in order to convert it into a soluble chloride of copper, from which it is again re-converted into the oxide by the agency of caustic lime. The precipitate is subsequently washed and filtered, and then laid out to dry in the air, but the temperature should not be allowed to exceed that of ordinary summer weather. When thoroughly dry the product will possess a beautiful blue colour.

CHEMISTRY OF THE FINE ARTS.—VII.

By Professor CHURCH, Royal Agricultural College, Cirencester.

THE RESTORATION AND PRESERVATION OF MURAL PAINTINGS—CHEMISTRY OF THE MATERIALS OF SCULPTURE AND ARCHITECTURE—MOSAICS—MARBLE—STONE, BRICK, AND TERRA-COTTA—WOOD.

IT is often desirable to preserve, for artistic or archæological reasons, the remains of those mural paintings with which, in mediæval times, our English churches were so profusely decorated. But great difficulties generally stand in the way of such preservation. Sometimes the plaster below the painting is in a thoroughly decayed state, crumbling on the slightest pressure, and in some cases the weakness is apparent in the layers of pigment themselves. Under the former conditions the only process of conservation involves the entire removal or transference of the painting to canvas or cloth: in the latter case, where the plaster is sound but the pigments loose, there is no plan which answers more thoroughly, and is easier of execution, than that of fixing the crumbling paint by means of a spray of some preservative solution. Before giving details of the successful application of this process, we must recur for a brief space to the process of transference before mentioned. When a mural painting has been cleared of the layers of whitewash which concealed it, and shows a good firm surface, though the plaster below is uneven and crumbling, it may, after careful dusting, be gradually transferred to a piece of cloth, which is to be wetted with smooth flour-paste just as it is gradually applied to part after part of the surface of the picture. Other materials of an adhesive nature, such as resin, have been employed for this purpose with success. When the cloth or canvas is quite dry, it may be loosened, together with its adherent painted layer, by the insertion of appropriate instruments (palette knives, etc.) between the layer to be removed and the plaster below. The other operations necessary to restore the picture are of a simple mechanical nature, involving the preparation of a bed of fresh plaster for its reception, and the final removal of the cloth on the face of the work by means of hot water. It may then be allowed to dry thoroughly, and finally submitted to the following treatment, which is equally appropriate in those instances where the paint on the surface is in a powdery and fragile condition, though the wall behind remains sound. All dust must be first removed by the bellows, or by a soft brush if the picture will bear it. Then the surface is to be dried, by means of a brazier or by burning spirit of wine upon it, but slowly and carefully, so that no flakes of colour curl up and separate. While still warm the surface is to be syringed (by means which we have pointed out in our remarks on Stereochromy) with a preservative liquid. A good preparation for this purpose is the wax or paraffine medium described in the last lesson. This material requires to be diluted with a good deal of the proper solvent (benzole or turpentine) before it is used for syringing. The liquid spray as it dries up fixes the loose particles and flakes of paint to each other and the wall, and though it darkens the colours a little, enriches them somewhat at the same time, while it exerts, it must be allowed, an unsatisfactory effect upon the whites and high lights of the picture. Preparations of parchment size or isinglass may be similarly employed in lieu of the paraffine or wax medium, but in a damp position these substances are likely to introduce a new element of decay, as they favour the growth of mildew upon the surface to which they have been applied. Nor is it usually safe to apply any preparation of the soluble silicates to an ancient mural painting executed in tempera or fresco, though such a proceeding has been once and again recommended. In trials made by the author of these papers it was found that water-glass solution produced the most undesirable changes of colour and surface in some fragments of mural decorations to which it was carefully applied. The process which we have described and recommended, and in which a spray of a chemically inert solution of paraffine or wax and resinous substances is used, seems to leave very little to desire. In some cases, where the colours and surface of the painting are firm and good, it may be simply painted over with a soft broad brush with such solutions as we have named. A simpler liquid preparation may even be used, of which paraffine and mineral turpentine are the sole constituents.

In now turning our attention to mosaic and tessellated work, we would first notice an erroneous idea which seems to prevail widely on the subject of the permanence of works executed in this manner. In wall and floor mosaics materials of very different degrees of texture and stability were and are employed as tesseræ—the little cubes or angular masses which constitute the materials at the disposal of the mosaicist. These coloured substances are either natural stones and marbles, or preparations of burnt clay or terra-cotta, or true porcelain, or else glass and enamel. While some of the natural stones and marbles of the most compact and insoluble kinds are but little influenced by damp and air, other sorts of an absorbent or mixed nature are very liable to disintegration and decay from frost and adverse atmospheric agencies. The older pottery tesseræ are not usually satisfactory, owing to their porous texture and the comparative ease with which they relapse into a soft mass not unlike the original clay from which they were made. The more modern tesseræ are of a much improved nature, especially those manufactured from nearly dry clay intensely compressed before burning. But the tesseræ of the hard porcelain, containing neither bone-ash on the one hand, nor excess of alkali on the other, leave nothing to desire in point of hardness and permanence, while they may be stained throughout their substance or near their surfaces only by those metallic oxides which are employed in glass and porcelain painting. Of the glass and enamel tesseræ a less satisfactory report must be given. The materials of which they are composed are generally remarkable for the quantity of alkaline and lead compounds which they contain. The carbon dioxide (carbonic acid) of the atmosphere acts upon these substances, in the course of time producing either a flaking off of the material itself, or else an incrustation upon its surface. No better illustration of this fact can be given than that afforded by the beautiful ruby glass which was occasionally employed in the Roman tessellated pavements found in this country. The tesseræ made of this glass are covered with a crust of green carbonate of copper and white carbonate of lead arising from the action just named. Thus the colour they now show is scarcely that which they were used to represent by the original artists. In the well-known and beautiful pavement at Corinium (Cirencester), the red poppies in the hair of Flora, and the blood dropping from the wounds of Actæon are of a malachite green. The very iridescence which often renders ancient glass so exquisitely beautiful is of itself no doubtful sign of decay. Film after film of the glassy surface becomes minutely streaked and pitted by the gradual removal of the alkaline bases of the vitreous material, until at last the whole substance of a vase, perhaps a quarter of an inch thick in parts, crumbles under the fingers to a mass of rainbow-tinted films. Enamels are no better than glass in this respect, often containing as they do still larger proportions of those constituents which aid in the process of decay. The oxide of tin which is introduced into them to confer opacity, exerts little or no favourable influence on their preservation, though in itself unalterable. We fear that we shall soon have evidence—in the fate of some mosaics recently executed in this country, and placed in positions where they are exposed to the weather—of the changes to which the apparently lasting materials of such works are really liable; and we must mention another matter in relation to mosaic work which hardly seems to have attracted attention. What guarantee have we of the permanence and continued binding power of the cement with which each tessera is held in its place? Without entering into details about such cements, which would indeed involve us in too long a digression, it may suffice to remark that the pure slaked but still caustic cream of lime which the Romans used for this purpose generally remains perfectly hard and firm after the lapse of 1,600 or 1,700 years. And it is reasonable to anticipate that if a hard and insoluble cement be once secured, it would be an admirable plan to saturate it when dry with a small quantity of pure and unalterable white paraffine, which might readily be driven by the aid of heat into the surface of the finished mosaic picture. A similar plan has sufficed in the hands of the author to restore to brilliancy, to waterproof, and to preserve from further change some fragments of Roman tessellated pavements which were rapidly falling to pieces.

The saturation of marble, especially of white statuary marble, with purified beeswax is an ancient practice which has been revived in modern times with some measure of success. But the bas-reliefs of the Wellington arch by Apsley House, which were thus treated under the direction of Faraday, and with every care, such as previous drying and warming, have not been able to resist very long the corrosive influence of a London atmosphere charged highly with the acid products of the combustion of coal. There can be no doubt that solid paraffine similarly used for the saturation of the marble would have exercised a much more lasting, if not a completely permanent effect. We have said enough in preceding lessons as to the selection and solution of the paraffine to be employed for such purposes as the present. Here, however, it may be convenient to note that it may be applied to stone not only in solution, but also in the state of fine powder laid on with a little water as a kind of paste, then allowed to dry, and finally driven in by the aid of heat. If it be desired to tint the marble, this may be done by previously incorporating the necessary pigment with the paraffine employed. This process is applicable not only to statuary marble, but to stone, wood, and many other materials. In the case of a font of alabaster which was gradually being dissolved away and corroded by the solvent action of the water in it, this fatal action was arrested by saturating the interior of the bowl with a fine coat of paraffine by means of heat. For decayed stonework and marble in ancient buildings the paraffine process forms perhaps a more complete and safe preservative than any of those numerous and varied aqueous solutions which have from time to time attracted public notice. It is also peculiarly adapted to the preservation of metallic surfaces from rust and corrosion; and in the case of iron objects of early date it has been used with great success by the author for many years past to preserve them without further alteration or disruption. For this purpose it is best to dry and warm the objects to be coated; they are then to be suspended in pure melted paraffine at a temperature of about 120° Centigrade, till all bubbles of vapour have ceased to be given off. The objects when lifted out and allowed to drain and harden will no longer admit of corrosion, while the scales or fragments of which they consist will be cemented together.

In default of any perfect process of waterproofing and hardening brick, terra-cotta, and stone, we may direct attention, though in a very brief manner, to that one method of which the writer of these papers has had most experience, and which indeed he gradually elaborated by experimental trials on public buildings. This process consists in the successive application of three solutions to the material to be waterproofed and hardened. Solution No. 1 is one of pure hydrate of baryta; No. 2 contains monocalcic phosphate, or soluble phosphate of lime; and No. 3 is a double water-glass mixed with some quantity of a dialysed solution of pure silica. Solutions 1 and 2 are applied alternately many times until no more can be absorbed; then, after a lapse of a day or so, one or two coats of No. 3 are given. The great feature of this process lies in the entire absence of any soluble salt. No such compound is formed in consequence of the changes which go on between the solutions themselves or between the solutions and the stone, etc. The surface of the stone is rendered smooth and slightly translucent in appearance, but is not discoloured, except it be of dark tint originally. In such a case, and where brick has to be treated, some suitable pigment, any of those which may be employed in stereochromy, should be mixed with the last coat of No. 3 solution just before it is laid on. Not only have brick walls and chimney stacks in the neighbourhood of the sea been rendered waterproof by this process, but it has been employed in the interior stonework of public buildings for the purpose, on the one hand, of preventing the soiling of stone by grease, soot, and clothes, and, on the other hand, for preventing the stone itself from being abraded by friction, and coming off in powder upon objects which may touch its surface. The drawback of the process is the tedious series of applications of three liquids which it involves. Neither water-glass, nor hydrofluosilicic acid, nor phosphoric acid, nor any of the other preparations which have been used or suggested for the purposes of preserving stone, actually fulfil the necessary conditions of success, as they are either ineffective, or else injure and disfigure the surfaces to which they are applied. A great desideratum would be supplied if a hardening, preserving, and waterproofing preparation could be obtained, which in one operation, or at all events by its use in the form of a single fluid only, could be readily applied to our stone and brick buildings. It must not discolour them, nor must it be of the nature of a paint. A solution of this kind is necessary in some places and under certain conditions, not only for stone, but also for terra-cotta. It is a mistake to suppose that this substance is practically impenetrable even when made of a satisfactory clay, well burnt, and with the kiln-face left untouched. Saline efflorescences and frost may exert upon it, as upon all materials not destitute of porosity, the most injurious disruptive influence. Under such circumstances it is of little use coating the surface with a repellant and waterproofing material; the sides and back of each block must be similarly treated before they are placed in position, that the entrance of the injurious liquids, etc., from behind may be effectually prevented. For the same reason the proper treatment of damp walls is seldom hit upon. And here another difficulty presents itself: the ashes used in the preparation of the plaster and mortar of such walls, instead of being clean and fresh, have often been used previously as absorbents of various decaying matters of animal and vegetable origin, and have become charged with the nitrates and sulphates which occur amongst the decomposition products of such matters. Where such ashes have been used in plaster, the task of rendering the wall sound and free from efflorescence is almost hopeless. Coating it with a water-glass cement after a thorough cleansing with warm rain-water has been attended in some cases with fair success.

Though there is no doubt that in many directions, not noticed in these papers, chemistry has rendered service to the fine arts, or is capable of doing so, yet we trust that the facts and suggestions which we have laid before our readers, even if incomplete, will yet aid those who work with the beauties of form and colour. It is certain that science and art will each benefit by a legitimate union.

SHIP-BUILDING.—XI.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF WOOD AND COMPOSITE SHIPS (*continued*).

In the preceding paper the disposition and fastenings of a wood skin, formed of one thickness of plank, were described at length, that being the common plan: we will now proceed to notice an arrangement where the skin is made up of three thicknesses of plank, as shown in Fig. 31. The planks in the two inside thicknesses, B, C, will be seen to be placed diagonally and to cross each other at right angles, whilst the outside layer, A, is worked longitudinally. With a skin so formed there is obviously no want of resisting power against strains tending to cause longitudinal sliding or shearing, such as exists in the skin of an ordinary wood ship. In fact, we have here a wood skin capable of transmitting and resisting strains in all directions, and requiring much less stiffening and framing than an ordinary skin. The system of construction is commonly known as the "diagonal" or "bread-and-butter" system. It has been used in many cases where the chief object has been to combine lightness with strength to an exceptional extent. The royal yacht *Victoria and Albert* and several of the light swift vessels of the Royal Navy have been constructed on this plan, as have also many merchant vessels, and it has given great satisfaction after full trial.

The framing in vessels built on the diagonal system is much lighter than that of ordinary ships. The middle-line arrangements are in some cases very similar to those previously described, but there are generally no timbers standing upon the floors, so that the spacing of the frames above the floor-head is much greater than in the usual plan. In other cases the frame is still further lightened, and iron braces are used to strengthen the skin. The work of building is no doubt made more difficult by adopting the diagonal arrangement, and this fact probably accounts for the comparatively limited use made of it. A skin so formed also requires great care in its fitting and fastenings. When the first layer of diagonal planking has been worked, it has to be secured to the timbers by a few fastenings, and lightly caulked before the second layer can be brought on; and this in its turn has to be secured to the timbers as well as to the inner layer, and caulked before the longitudinal planking can be fitted. All three thicknesses are ultimately bound together by through-bolts clenched inside and outside, and are secured to the timbers by metal screws, dumps, or through-bolts. But when properly fitted and fastened the united layers form a thoroughly efficient skin, and with comparatively little weight give great strength of hull.

Large boats for the Government service are commonly built upon a plan slightly differing from that illustrated in Fig. 31. Their skins are formed of two thicknesses of planking, wrought diagonally just as B and C are in the diagram. Their only framing consists of light floors stretching out to the bilge, and yet so great is the strength of the skin that they are found capable of bearing rough usage and carrying very heavy weights, without any sensible change of form or other serious damage. It should be added that in building these boats the planking is wrought upon a light framework of suitable form, capable of being removed with ease when the work is sufficiently advanced.

A few light river steamers have been built with one thickness of planking, the strakes of which were worked longitudinally as on the ordinary plan, and connected together by numerous edge-bolts. Frames were almost entirely dispensed with, strong diagonal iron riders and straps being employed to strengthen the skin. This plan is said to have answered fairly in the vessels so built, but it scarcely appears capable of successful application in sea-going vessels, which are necessarily subjected to much more severe strains than those river steamers have to bear.

Considerable importance attaches to the *caulking* of the skins of wood ships, and a few words respecting it will not be out of place. The operation consists simply in driving threads of oakum, the number of which varies with the thickness of the planking, into the spaces between the edges and butts of adjacent planks. These spaces or "seams" should be so formed as to taper gradually toward the inner surfaces of the planks, where the adjacent edges should touch each other; and when the oakum is driven in the seams should be compactly filled and made water-tight. The latter object is partly attained by "paying" over the seams with pitch after the oakum is in place. Pieces of plank are sometimes cut out at different parts of the bottom of a ship in order to test the efficiency of the caulking. However tightly the oakum may have been driven at first, it will probably become slack after a vessel has been a few years at work, this slackness being due in part to shrinkage in the planking, and in part to the unavoidable working of the vessel when at sea. One of the most common features in the refit of wood ships is consequently the re-caulking of their bottoms, which renders them not only tighter, but also stronger.

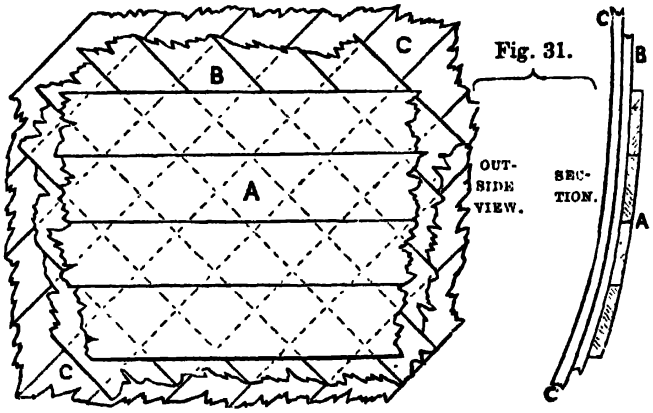


Fig. 31.

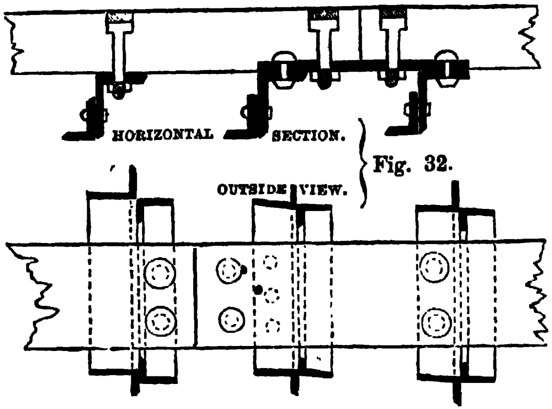


Fig. 32.

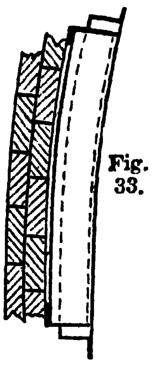


Fig. 33.

Turning next to the skins of composite ships, it will be proper to take first the most common arrangement where the planking is in one thickness. So far as the general disposition and the shift of butts is concerned, there is no difference between this plan and that illustrated by Fig. 27, page 256. Three passing strakes occur between consecutive butts, and "steps" are carefully avoided. Instead of being placed *upon* the frames, however, the butts are placed *between*, and usually secured as shown in Fig. 32, a plate of iron, termed a "butt-plate," being riveted to the adjacent frames in order to support the butt and receive its fastenings. This plate is of the same breadth as the planks it helps to connect. Each butt-end is secured by two bolts, with nuts hove up, inside the butt-plate, on screw-threads cut for that purpose. The heads of these bolts are formed as shown to give good holding power, and are sunk into the planking, so that they may be covered with wood plugs. Great care should be taken in driving the bolts and fitting the plugs in order to make the bottom tight. The sketch shows also how the planking is secured to the frame angle-irons, by means of nut-and-screw bolts similar to those at the butt, the nuts being hove up inside the flange of the angle-iron. Double fastening is shown in this case, and it is that suggested by Lloyd's Committee for planks more than 10 inches broad; double and single fastening alternately would be allowed in planks from 8½ inches to 10 inches broad, and single fastening in planks under 8½ inches in breadth. In all cases, however, double-butt fastenings like those in Fig. 32 are required; and it will be clear that this method of securing the butts gives greater strength against tensile strains than that usual in wood ships. The butt-plate, in fact, straps or "fishes" the butt in a far better way than the frame-timber of a wood ship; and the butt-bolts are better arranged in the composite skin. But even with this improved connection it cannot be expected that a butted-strake, such as is shown in Fig. 32, can be thoroughly efficient against severe tensile strains, the ultimate effect of which would undoubtedly be to open the butt by tearing away the short-grained wood left between the bolts and the butt. It should be added that in some few composite vessels butt-plates have not been used, but plain scarfs employed instead of butts, in order to make a good connection.

Composite ships with one thickness of planking obviously require to be strengthened by diagonal ties on the frames, just as wood ships require diagonal riders. The usual plan is to have two sets of diagonal tie-plates riveted upon the outside of the frames, and crossing each other at right angles. The upper ends of these tie-plates are connected with a strake of plating, named the "sheer-strake," fitted in wake of the upper deck beams, and their lower ends are secured to a strake of plating worked near the bilge at the height where the floor-plates end. By this means the skin is much aided in resisting longitudinal sliding or shearing, against which the caulking, when tight, is also a great help.

The composite system was devised in order to combine greater strength than wood ships possess, with an equal freedom from foulness of bottom, and for the latter purpose metal sheathing, usually of copper or Muntz metal, is nailed to the planking up to a few feet above the load water-line. It has already been remarked that the great danger incurred by this plan is the setting up of galvanic action between the metal sheathing and the iron portions of the hull, which action necessarily leads to the more or less rapid deterioration of the iron. Experience proves that even with the greatest precautions it is difficult to avoid metallic connection between the sheathing and the iron portions of the hull, especially when only one thickness of planking is used; and in cases where less care is taken the damage to the iron is often both serious and rapid. For example, it is very common to use iron bolts in fastening the planking, their surfaces being often "galvanised" or coated with zinc to protect them from rust, and their heads let into the planks and covered by plugs, as shown in Fig. 32; and in such cases the wasting of the bolts to a very serious extent is not at all unusual after a short period of service. Copper or metal bolts are sometimes used instead of iron, and are, on the whole, much to be preferred; but they are not free from disadvantage, because, as usually fitted, they form a direct metallic connection between the sheathing and the iron frames, and may cause damage to the latter; besides which they are much more expensive than iron. In fact, after full trial, many ship-builders have formed the opinion that it is necessary to employ two thicknesses of planking in the skins of composite ships with copper or metal sheathing, in order to prevent serious galvanic action and to secure proper durability. Others have advocated the disuse of such sheathing, and the substitution for it of zinc, urging that the bottoms would thus be kept clean, while no evil would result to the iron portions of the hull if galvanic action were set up, the zinc sheathing then wasting instead of the iron, and being easily replaced. The balance of opinion appears at present to be in favour of the continued use of metal sheathing, and we will therefore glance at some of the arrangements adopted when the skin planking is worked in two thicknesses.

One of the most common plans is illustrated in Fig. 33; both thicknesses being worked longitudinally, and the seams of the planks in one layer being brought upon the centres of the planks in the other layer, the two sets thus mutually supplying the direct edge connection which is wanting in a wood skin worked in one thickness.

Another arrangement consists in working both layers of planking diagonally (like B and C in Fig. 31). Diagonal tie-plates are not fitted on the frames when this plan is followed, and they are obviously unnecessary, the skin being capable of acting alone in resisting longitudinal shearing strains.

Still another plan consists in working one layer (either the inner or outer) diagonally, and the other longitudinally; in most cases the outer planks are worked longitudinally. In all three plans both thicknesses of planking must be caulked, and between the two it is usual to fit felt, waterproof glue, or some similar material. The inner thickness is fastened to the frame angle-irons by iron nut-and-screw bolts; and the outer thickness is secured to the inner by short copper or metal bolts, either with nuts on the inner ends or clenched upon rings on the inside of the planking. The fastenings of the outer thickness are placed in the frame-spaces, clear of the frames and the fastenings of the inner thickness, so that the probability of any galvanic action being set up between the metal sheathing and the iron frames, etc., is much reduced. The cost of building a vessel with two thicknesses of planking is of course greater than that of building with one thickness; but there is reason to believe that the additional outlay is more than repaid by the increase in durability and efficiency.

It is usual to have the garboard strakes in one thickness, even when the greater portion of the skin is in two thicknesses; and it is by no means uncommon to terminate the double thickness at a moderate height above the load water-line of the vessel, the remainder of the upper works being covered with one thickness of planking. The latter practice has no such attendant disadvantages as the use of a single thickness under water entails, and it lessens the cost of construction. In some cases this topside planking is replaced by iron plating down to six or eight feet from the load line, but this is not a common plan, nor does it seem on the whole preferable to the other.

Some eminent authorities have expressed great doubts as to the efficiency of the skins of composite ships, and the general strength of their structure. As compared with the skins of iron ships, those of composite ships are undoubtedly inefficient against some classes of strains; but they compare favourably with those of wood ships, especially when wrought in two thicknesses. Severe and extended trials have, moreover, shown that composite ships are fully capable of resisting the strains brought upon them when at sea; and the fact that the far-famed China tea-ships which race home yearly under an enormous spread of canvas, continue to perform their duties satisfactorily without displaying signs of working or weakness, furnishes a very strong argument in favour of the sufficiency of the strength of composite ships. In short, their continued use or their disuse is likely to be settled rather by considerations of cost and durability than by those of structural strength.

The arrangements of the inside planking or ceiling of composite ships are identical in character with those of ordinary iron ships, and it will consequently be preferable to defer any remarks on that subject to a later paper.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXVI.—DAVID MUSHET.

BY JAMES GRANT.

THOUGH the existence of ironstone in the Scottish coal measures was known for many years before the year 1760, when, as we have related in the memoir of Dr. Roebuck, the Carron works were established, no attempt was made, until then, to turn it to [illegible] Only one kind of ironstone was then used, viz., the argillaceous, or "clay-band;" for the more valuable and carbonaceous was unknown until the year 1801, when it was discovered by David Mushet, a native of the little town of Dalkeith, six miles from Edinburgh. He was born there in 1772, and though but the son of a labouring man, was descended from an old historical stock, the Mushets who resided in Kincardine, on the estates of the Montrose family. In the time of Charles II., all these Mushets, save two, perished of the plague, and one of these, the Rev. George Mushet, who accompanied the great Marquis of Montrose in nearly all his campaigns as chaplain, died early in life, and is buried in the churchyard of Kincardine; but the name can be traced far back in Scottish history, as they are descended from William de Montefixo, who held the lands of Uchreardore under Robert I., and others in the thanedom of Cluny under David II.

At the age of nineteen, David Mushet, who like most of his family had been brought up as a metal founder, obtained employment at the Clyde Iron Works, near Glasgow, as accountant of the company, which had then but two blast-furnaces at work. Though he had nothing to do with the mechanical operations of the firm, being of a thoughtful and speculative turn of mind, the remarkable conversions undergone by iron in the various processes of manufacture soon began to occupy his attention, and he joined in the occasional discussions of that subject held by the more intelligent of the young men employed about the works, and Fourcroy's book was frequently referred to by them with reference to certain questions of difference which arose among them in the course of their inquiries.

In 1793, when the establishment of the company was reduced, David Mushet finding that he was almost the only occupant of the office, resolved to commence a few experiments, and to acquire a perfect knowledge of assaying as the true key to the method of iron-making "He first set up his crucible upon the bridge of the reverberatory furnace used for melting pig-iron," says Mr. Smiles, "and filled it with a mixture carefully compounded according to the formula of the books; but notwithstanding the shelter of a brick, placed before it to break the action of the flame, the crucible generally split in two, and not unfrequently melted and disappeared altogether. To obtain better results, if possible, he next had recourse to the ordinary smith's fire, carrying on his experiments in the evening after office hours. He set his crucible upon the fire on a piece of fire-brick, opposite the nozzle of the bellows, covering the whole with coke, and then exciting the flame by blowing. This mode of operating produced somewhat better results; but still neither the iron nor the cinder obtained resembled the pig or scoriæ of the blast-furnace, which it was his ambition to imitate. From the irregularity of the results, and the frequent failure of the crucibles, he came to the conclusion that either his furnace or his mode of fluxing was in fault, and he looked about him for a more convenient mode of pursuing his experiments. A small square furnace had been erected in the works for the purpose of heating the rivets and for the repair of the steam-engine boilers. The furnace had for its chimney a cast-iron pipe of 6 or 7 inches in diameter, and 9 feet long. After a few trials with it, he raised the heat to such an extent that the lower end of the pipe was *melted off*, without producing any very satisfactory results on the crucible, and his operations were again brought to a standstill."

For two years Mushet continued to make experiments in the art of assaying, and during that time he wrought entirely in the method detailed by past experimentists in their books; but certain that all his results were somewhat negative, he cast books aside, and resolved to work upon a system of his own, the result of which, he was assured, would be similar to those produced by the blow-furnace. All these repeated attempts had to be made in the night, as all the hours of the day were fully occupied by quill-work in the company's office; but he eventually succeeded, and he became acknowledged as a well-skilled assayer in iron, and whenever a difficulty occurred in the smelting of any new ironstone, "the manager himself resorted to the book-keeper for advice and information;" and the skill and experience he had gathered during his nightly labours enabled him readily and satisfactorily to solve the difficulty, and suggest a suitable remedy."

He was now permitted by the company to have an assay-furnace of his own, at which he continued to make his experiments, while at the same time he instructed the son of the manager in the art of assaying, devoting, at times, entire nights to experiments in assaying, in roasting and cementing iron ores and iron stones, decarbonating cast iron for steel and bar iron; working thus till three a.m., and leaving instructions with the engine-man to call him at half-past five, so that he might be at his desk by six!

In the midst of his arduous career of investigation, as he tells us in his "Papers on Iron and Steel," published in London in 1840, without any cause or motive being assigned, but probably through some whim or caprice, he was ordered to stop; and, by direction of the manager, his furnaces were demolished, with an edict that they were not to be erected again! This ended all his hopes of research at the Clyde Iron Works. However, he erected, with the consent of a friend, an assay and cementing furnace, on a piece of ground two miles distant from these works, and thither the unwearying Mushet was wont to repair in the night, and during the hours allotted by others to their meals, for a whole summer; but the labour proved too great, and the results too uncertain to be continued longer. At the close of 1798 he quitted the Clyde Works, and constructed several furnaces, and for two years continued his investigations in connection with the alloys of metals.

"Though operating in a retired manner, and holding little communication with others, my views and opinions," he relates, "upon the *rationale* of iron-making, spread over the establishment. I was considered forward in affecting to see and explain matters in a different way from others who were so much my seniors, and who were *content* to be satisfied with old methods of explanation, or with no explanation at all. . . . . Prejudices seldom outlive the generation to which they belong, when opposed to a more rational system of explanation. In this respect Time, as my Lord Bacon says, is the greatest of all innovators. In a similar manner *Time* operated in my favour in respect to the black band ironstone."

In the year 1801, when crossing a stream called the Calder, in Old Monkland, in the Middle Ward of Lanarkshire—a soil abounding in mineral treasures—Mushet picked up a specimen of this most valuable description of ore, which chanced to attract his eye as it lay in the bed of the river. He subjected it to his crucible, and on being fully satisfied as to its properties, he next proceeded to discover its geological position and relations, and finding that it belonged to the upper part of the coal formation, he designated it carboniferous ironstone; and he further discovered that rich beds of the mineral were in most of the western counties of Scotland. Analysis proved it to contain over 50 per cent. of protoxide of iron; while the coaly matter it contained was not its least valuable ingredient, as by the aid of the hot-blast it may be smelted without *any* addition of coal.

In the year of his discovery, Mushet was engaged in erecting for himself and his partners the Calder Iron Works, and great prejudice was excited against him by all the ironmasters at the time, for daring to class "the wild coals" of the country, as black band was called, with ironstone fit and proper for the blast-furnace. Yet that discovery enabled Scotland to take a high rank among the iron-working nations of Europe; and seams of the same coal have since then been discovered in North Wales and in Staffordshire.

From the establishment of the Carron Works in 1760 till 1788, the quantity of iron produced by Scotland did not exceed 1,500 tons per annum; but it has steadily risen since then, and the total quantity made in the year 1867 amounted to 1,031,000 tons; but ten years previous, the largest quantity of ore put out in one year was 2,500,000 tons. Now, thanks to the discovery of David Mushet, the west of Scotland, more particularly the district about Old Monkland, has made an unparalleled advance in population and prosperity. To this, of course, the introduction of the hot-blast and the increasing demand for iron for railway purposes have added. In that district which was once so pastoral and lonely, there is everywhere heard the brattling of machinery, the sonorous strike of mighty hammers, and the hissing and clanking of the steam-engine. Dense clouds of smoke roll over it incessantly; a coat of black dust lies over everything, and the flames of the blast-furnaces, for ever belching with wild and weird effect, but chiefly at night, have won for that district the somewhat appropriate title of "the Land of Fire."

"Fortunes have been realised there in the iron trade," says a statist, "with a rapidity equalled only by the sudden and princely gains of those who accompanied Pizarro to Peru. It is understood that the clear profits of a single establishment in this line during the year 1840 alone were £60,000; though less than twenty years previous the co-partners of this company were earning their bread by the sweat of their brow, in following the agricultural vocation of their fathers."

"Such," says Mushet himself, "are the consolatory effects of time, and the discoverer of 1801 is no longer considered the intrusive visionary of the laboratory, but the acknowledged benefactor of his country at large, and particularly of an extensive class of coal and mine proprietors and iron masters, who have derived, and are still deriving, great wealth from this important discovery, and who, in the spirit of grateful acknowledgment, have pronounced it worthy of a crown of gold, or a monumental record on the spot where the discovery was first made." But he adds elsewhere, with some bitterness of heart, "whilst the exploits of the conqueror and the intrigues of the selfish demagogue are faithfully preserved through a succession of ages, the persevering and unobtrusive efforts of genius, developing the best blessings of the Deity to man, are often consigned to oblivion!"

David Mushet, in addition to many papers in the *Philosophical Journal*, contributed largely to other scientific works. He wrote the article "Iron" for Macvey Napier's supplement to the Edinburgh edition of the *Encyclopædia Britannica*, and the articles "Blast Furnace" and "Blowing Machine" for Rees' *Cyclopædia*, both of which were frequently quoted in Parliament when, in 1807, it was proposed to levy a tax on iron.

Mushet discovered a mode for the preparation of bar-iron by a direct process, combining iron with carbon; he discovered also the beneficial effects of oxide of manganese on iron and steel; the uses of oxide of iron in the puddling-furnace in various modes of appliance; the application of the hot-blast to anthracite coal in iron-smelting, and the production of pig-iron from the blast-furnace suitable for puddling without the intervention of the refinery.

In 1800 he patented his process for combining iron with carbon for the production of steel; and afterwards, when he discovered the beneficial effects of oxide of manganese on steel, "Mr. Josiah Heath founded upon it his celebrated patent for making cast steel, which had the effect of raising the annual production of that metal in Sheffield alone from 3,000 to 100,000 tons. His application of the hot-blast to anthracite coal, after a process invented by him and adopted by the Messrs. Hill, of the Plymouth Iron Works, South Wales, had the effect of producing savings equal to £20,000 a year at those works; and yet," says Smiles, "strange to say, Mr. Mushet himself never received any consideration for his invention."

While David Mushet lived he was a leading authority on all matters connected with steel and iron, and he closed a laborious and useful life in 1847, at the age of seventy-five years.

PRINCIPLES OF DESIGN.—XXIX.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

HARDWARE (*continued*).

IN ironwork the manifestation of a true constructive principle is beyond all things desirable. Iron, being a strong material, should not be formed into heavy masses unless immense weight has to be sustained or very great strength is required. If we form lamps, candelabra, and such works of iron, it is obvious that the portions of metal employed in their construction may be thin, as the material is of great strength. Were we to form such works of wood, then a greatly increased thickness of material would be necessary, in order that the same strength be secured, as wood is not nearly so strong as iron.

My remarks will have special reference to wrought iron, as cast iron cannot so fully be said to have a constructive character. A small railing (Fig. 133), which we engraved in our last article (page 217), is an admirable illustration of a true constructive formation, as the parts are all held together, and strengthened to a wonderful degree, by the introduction of a horseshoe-shaped member. This railing is worthy of the most careful study, for its strength is great. Besides strength we have also beauty. The horseshoe form, especially when judiciously applied, is far from being offensive. Utility must come first, and then beauty, and so it does in this particular railing, but here we have great simplicity, and a correct structural character has been arrived at in its production rather than any elaboration of the principles of beauty.

From the catalogue of J. W. Dovey, of John Dalton Street, Manchester, I select an illustration of structure in the form of a candelabrum which is highly satisfactory in character as a simple work (Fig. 138). There is a solidly-formed heavy base, an upright stem terminating in a candle-holder. There is an arrangement for catching waste grease, and extra strength is given to the stem by four slender buttress-like brackets, which are securely and well attached to the base below and to the stem above; and these are strengthened by two hoops, which prevent their bending under pressure.

Figs. 139 and 140, the former being a ridge or wall cresting, and the latter a stair railing, are each illustrations of a correct treatment, inasmuch as strength (a structural quality) and beauty (an art quality) are secured at the same time. Fig. 139, it may be noticed, is admirably constructed, only it is a little slender above the middle horizontal line. These two illustrations are also from Mr. Dovey's excellent catalogue.

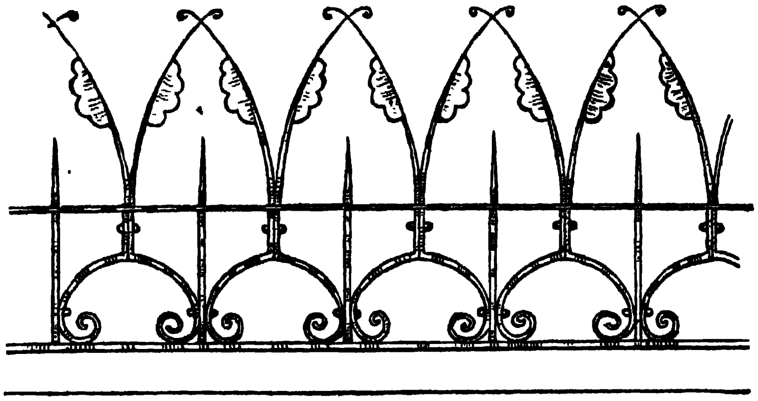


Fig. 139.

In the catalogue just named, and in those named in my last article also, many good examples may be found illustrative of the successful combination of true structural qualities with a considerable amount of beauty, and also acknowledging the strength of the material by the lightness of the parts.

Those who reside in or visit London, will do well to go to the South Kensington Museum, and study a large and splendid candelabrum of Messrs. Hart, Son, and Peard, which is well worthy of consideration. It is rather heavy, and is of enormous strength,

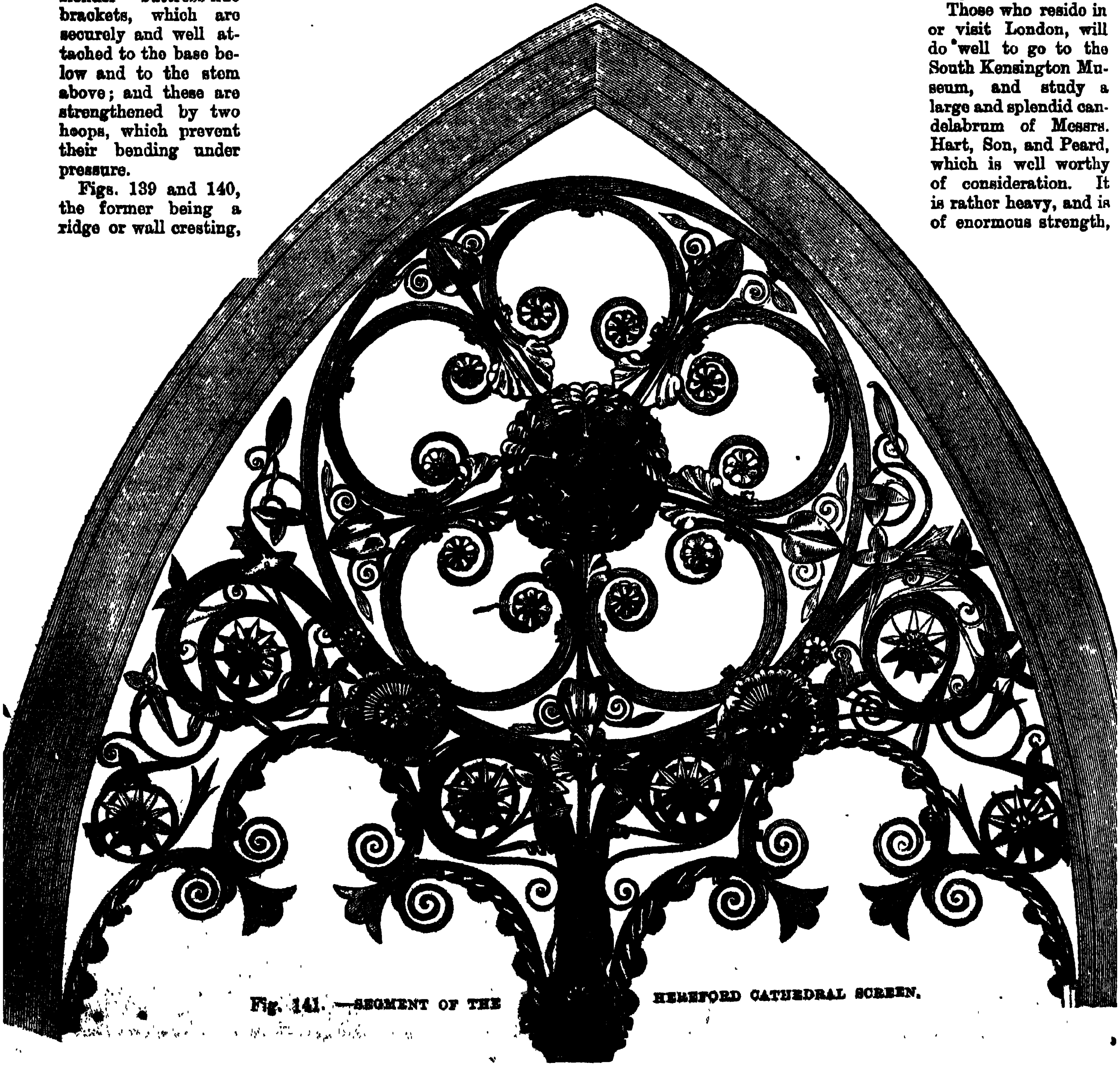


Fig. 141.—SEGMENT OF THE HEREFORD CATHEDRAL SCREEN.

but in most other respects it is highly commendable. It is beautiful, well proportioned, and illustrative of a correct treatment of metal. Besides this, it exemplifies the manner in which stones or jewels may be applied to works in hardware with advantage. As a further illustration of a correct and very beautiful treatment of metal we give one segment of the Hereford Cathedral Screen (Fig. 141), the work of that most intelligent of metal-workers, Mr. Skidmore of Coventry. This screen was shown in the International Exhibition of 1862, in London, and was from there removed to its place in the cathedral. All who can will do well to view this beautiful work, which is one of the finest examples of artistic metal-work with which we are acquainted. Notice the ease with which iron may be treated if a correct mode of working be employed. Let a bar of iron be taken which is about half an inch thick, by 1¼ broad. This can be rolled into a volute (the filigree mode of treatment), or its end can be hammered out into stems and leaves, and to it can be attached other leaves by rivets, screws, or ties, or it can be bent into any structural form. To the student I say, study the shapes into which simple bars of iron can be beaten, both mentally, and by observing well-formed works.

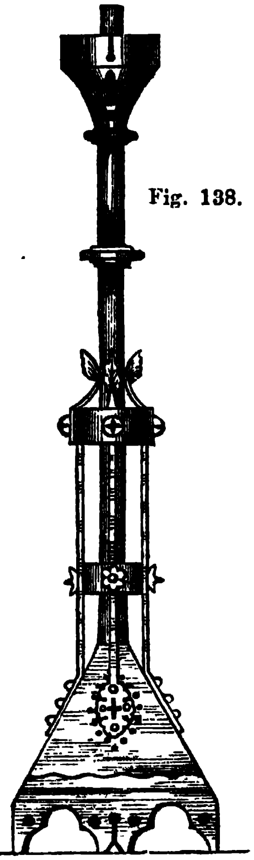
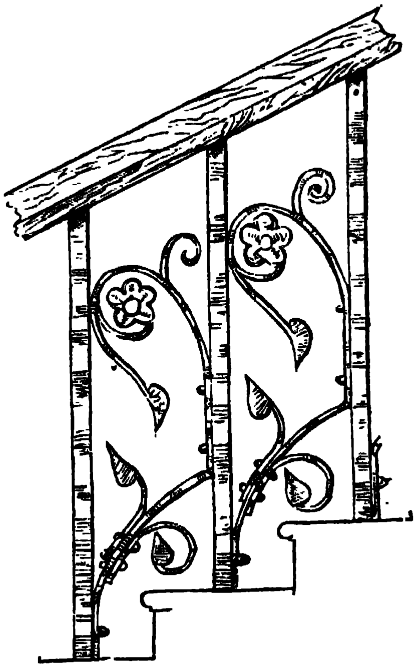


Fig. 138.

Brass, copper, and other metals may be associated with iron in the formation of any works. If well managed, brass and other bright metals may act as gems—that is, they may give bright spots; but where the bright metals are used with this view, care must be exercised in order that the bright spots be formed by beautiful parts, and that their distribution be just, for that which is bright will attract first attention.

Before leaving this part of our subject, I must call attention to a hinge by Hardman, of Birmingham, which was shown in the International Exhibition of 1862, as it is both quaint and beautiful (Fig. 142). The door to which this hinge was applied opened twice; the first half opened and folded back on the second half, and then the two halves opened as one door, as will be seen from our illustration. It is very desirable that we have a little novelty of arrangement in our works. We are too apt to repeat ourselves, hence it is a sort of relief to meet with a new idea.

Fig. 140.



It is impossible that I take up each article of hardware and consider it separately. All I can do is to point out principles, and leave the learner to consider and apply them for himself—a principle which, once understood, may result in the construction of many excellent works, and may lead to the formation of a correct judgment respecting such objects as may be brought forward for criticism. I will, however, just call attention to gas-branches, as they are often wrongly constructed. A gas-branch is a duct through which gas is to be conveyed. It must be strong if it is to be exposed to pressure, or if it runs the chance of coming in collision with the person, as do standard lights in public buildings. The main part of a gas-branch is the tube or pipe which is to convey the gas, but this may be supported in many ways, as by such buttress-like brackets as in the candelabrum shown in Fig. 138; and if there are branch tubes for several lights, these may well be connected with the central tube, not only by their own attachment, but by brackets of some sort, or with one another by some connecting parts. Whether the gas-branch be pendent or standard, this mode of strengthen-

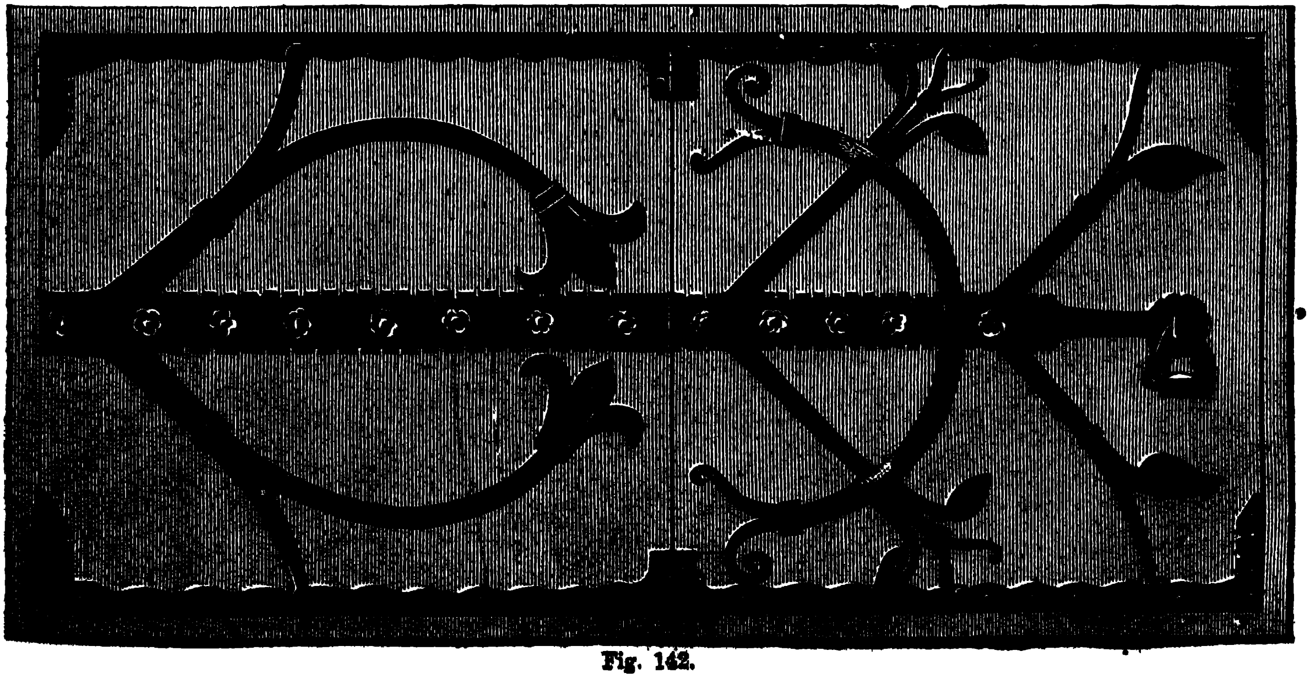


Fig. 142.

ing the tube-work should be employed, for the tubes themselves are but slightly held together, and by pressure being brought to bear upon them, a dangerous and expensive escape of gas may result.

In the manufacture of gaseliers one or two Birmingham houses have certainly distinguished themselves by the production of works both beautiful and true; and these lead me to think that a better day is dawning for Birmingham, in which its art shall be exalted rather than degraded, and shall be such as will win to it the esteem of the world rather than call forth the execrations of art-loving people.

As to the colouring of iron I can say little. In my judgment the best modes of colouring metals were originated by Mr. Skidmore of Coventry, of whom I have before spoken. His theory is this, that metals are best coloured by the tints of their oxides. When a metal, especially brass, is seen in a furnace in a molten condition, the flames, where the oxygen of the atmosphere is uniting with the vapour of the metal, present the most resplendent tints. The same thing in a lesser degree occurs in the case of iron, but here the colours are less brilliant, and are more tertiary in character. Mr. Skidmore applies to a metal the colours seen in the flames of the furnace where it melts. Without attempting to limit the colourist to any theory whereby his ideas might be restricted, I must say that Skidmore's colouring of the metals is very good.

SEATS OF INDUSTRY.—XXV.

NEWCASTLE-UPON-TYNE.

BY WILLIAM WATT WEBSTER.

THE importance of coal as an agent in modern domestic, manufacturing, and commercial economy can hardly be exaggerated, and no country in the world has reaped so much benefit from its possession and use as Great Britain. It is to the richness of our coal-fields, and to the industry and skill with which they have been worked, that we owe in a great measure our manufacturing and commercial prominence among the nations. "We are living," as Robert Stephenson once said, "in an age when the pent-up rays of that sun which shone upon the great carboniferous forests of past ages are being liberated to set in motion our mills and factories, to carry us with great rapidity over the earth's surface, and to propel our fleets, regardless of wind and tide, with unerring regularity over the ocean." It is calculated that about 70,000,000 tons of coal are now annually raised in the United Kingdom, and the coal-mines of Durham and Northumberland produce about one-third of this total. Newcastle-upon-Tyne is the capital of Northumberland, and the port from which the coal excavated in that county, and in the neighbouring county of Durham, is exported to other parts of Great Britain and to foreign countries. It is the principal centre of the coal-trade in England, and to a great extent it is indebted for its prosperity to the convenience of its situation as a port of shipment for the coal found in the neighbouring districts.

The history of Newcastle stretches back to the time of the Roman occupation. It was one of the stations on the wall erected by the order of the Emperor Adrian, A.D. 120, to defend the Roman provinces from the incursions of the Caledonians, and which traversed the island from the Solway Firth to the Tyne, terminating at Wallsend, about three miles to the east of Newcastle. The place was named Pons Ælii by the Romans, from a bridge built over the river by the same emperor, and called by his family name. Round this bridge the first nucleus of Newcastle was formed. About the year 208 A.D., the Roman wall originally constructed by Adrian was rebuilt by Septimius Severus, after a repulse he suffered from the Caledonians. From the fact that cinders are frequently found among the remains of Roman stations in Northumberland, it would seem that the use of coal was not unknown to the Romans, although the abundance of timber probably restricted its use to neighbourhoods where it was obtained at or near the surface. After the departure of the Romans from the island, the Anglo-Saxons expelled the Britons from this part of the country, and founded the kingdom of Bernicia. In the immediate vicinity of Pons Ælii the Saxon kings had an occasional residence, called Ad Murum, and after the conversion of the Saxons to Christianity the deserted Roman camp was occupied by a colony of monks, from whom it derived the name *Moncaster*, or *Monkchester*. At that period it was the resort of numerous pilgrims, who came to the holy well of Jesus Mount, now Jesmond, about one mile to the north-east. Owing to the incursions of the Danes, the monks were compelled to abandon the place, and it fell into the possession of the Scots.

No satisfactory evidence that coal was either an article of commerce or of domestic use during the Saxon period has been discovered. Shortly after the conquest of England by William of Normandy, the Scots were driven from their settlement on the Tyne by Robert, the eldest son of the Conqueror, who in 1080, during the lifetime of his father, hastily built a castle there on his return from a hostile excursion into Scotland. At that time the town received the designation it now bears. This castle was rebuilt by William Rufus, who also surrounded the town with walls, and conferred peculiar privileges on its inhabitants. The benefits conferred on the town by William II. are commemorated in the following rude lines in Hardynge's "Chronicle:"—

> "He builded the New Castle upon Tyne,
> The Scottis to gainstand: and to defend
> And dwell therein the people to incline,
> The town to build and wall, as did append,
> He gave them ground, and gold full great to spend,
> To build it well and wall it all about;
> And franchised them to pay a free-rent out."

The present castle, however, which is the best example of Norman military architecture in England, was erected by Henry II., between the years 1172 and 1177. A charter is said to have been granted to the town by King John, but the earliest charter extant is that of Henry III., dated 1234, in which, "upon their supplication," the inhabitants are granted the privilege "to dig coals and stones in the common soil without the walls, and to convert them to their own profit, in aid of their free-farm rate of £100 per annum." In the reign of Edward I. Newcastle was captured and burned by the Scots, it having been used by that monarch, and by his successors Edward II. and Edward III., as a rendezvous for the great armies with which they attempted to conquer Scotland. Portions of the walls constructed after this disaster still remain. During the reign of the last-mentioned king, Newcastle successfully resisted an attack made on it by the Scots under David Bruce, and in 1299 the walls on the eastern side were rebuilt. At this early period Newcastle was one of the most important commercial ports in the kingdom, and was noted as a nursery for seamen, and as a resort for merchants and tradesmen of all classes.

The introduction of sea-coal as household fuel encountered an intense and prolonged opposition. It was believed that the smoke from coal was injurious to health, and so strong was this prejudice, that in the reign of the first Edward a man was hanged for having burned it within the walls of London. In accordance with a petition presented to Parliament, the king issued a proclamation, in 1316, prohibiting its use in the metropolis, and as this did not prove effectual, recourse was had to severer measures. Fines were imposed on a first conviction for burning coal, and the penalty for a second offence involved the destruction of the furnaces, etc. But coal would seem to have made gradual progress in spite of all that could be done to suppress its use. In his "Agriculture and Prices in England," Mr. Roger says:—"The appearance at so distant a place as Dover, in 1279, the earliest entry that has come under my observation, suggests that the coasting traffic in this article must have been familiar. It was purchased for the use of the castle, and must, of course, have been burned in a fire-place with chimney. It may be added that among the various traders given in the taxing-bill of Colchester, 'Rot. Parl.,' vol. i., sea-coal dealers are mentioned at the close of the thirteenth century." In 1280 Newcastle had a considerable trade in coal, and soon afterwards it was introduced into London, although at first it was burned only by smiths, brewers, soap-boilers, dyers, etc. The exportation of coal from Newcastle to foreign countries is believed to have commenced about the year 1325. In 1346 the port supplied, on the requisition of Edward III., 17 ships and 314 mariners for the siege of Calais, a larger force than was furnished by any port north of the Thames, Yarmouth alone excepted. Eleven years later this monarch granted to the inhabitants of Newcastle the entire possession of the Castle Moor and the Castle Field adjoining, "for the purposes of there digging of coals, stone, and slate." Towards the close of the fourteenth, and during the earlier years of the fifteenth centuries, there flourished in Newcastle one of the most eminent merchants of his time, Roger Thornton, "the richest merchant that ever was dwelling in Newcastle," who was three times mayor, and three times member of Parliament, and did much to develop the trade and further the interests of the town. It prospered and increased steadily all through the fifteenth century, and under the Tudors in the sixteenth century the chief trade of the town consisted in the exportation to the Continent of "canvas, sheepskins, lambsfelts, lead, grindstones, coals, and rough-tanned leather." The manufacture of glass was first introduced into England in the reign of Queen Elizabeth, by a body of immigrants from Germany, who established themselves in the neighbourhood of Newcastle.

In the reign of Charles I. Newcastle suffered two severe afflictions. It was visited by the plague in 1636, which carried off 5,000 of the inhabitants; and in 1640 it was surprised and captured by the Scottish army under General Leslie. During this king's reign the use of coal became universal in London. Newcastle espoused the cause of Charles I. against the Commonwealth, and was garrisoned by the Royalists during the Civil War; but at a late period it again fell, after a prolonged siege, into the hands of the Scotch, then in alliance with the Parliament. The author of "Chorographia; or, a Survey of Newcastle-upon-Tyne," writing in the time of the Commonwealth, says:—"Many thousands are engaged in this trade of coals; many live by working of them in pits, and many live by conveying them in wagons and wains to the river Tyne." Some idea of the magnitude of the Newcastle coal-trade at the beginning of the eighteenth century may be formed from the report made by the Master of the Newcastle Trinity House to Parliament, which states that 600 ships, each carrying 80 Newcastle chaldrons of coal, and navigated by a total of 4,500 men and boys, were required for the supply of other ports with that article.

The progress of the coal-trade, and with it the prosperity of Newcastle, were for a long period impeded by the creation of monopolies, and the imposition of oppressive regulations and exactions. From a very early period the Corporation of London had undertaken the task of weighing and measuring the coal brought to the metropolis, and had charged eightpence per ton for their trouble. The power to make this charge was confirmed to the City by charter in 1613. In the reign of Charles I., two monopolies, still more directly affecting the interests of Newcastle, were granted. Sir Thomas Temple and his partners were, in 1637, assigned the exclusive right of selling all the coal exported from Newcastle for twenty years from that date; and in the following year a company of monopolists was empowered to buy all the coal produce of Newcastle, Sunderland, and Berwick, and to sell it in London for any price not exceeding the very high rate of seventeen shillings per chaldron in summer, and nineteen shillings in winter, one shilling per chaldron being the king's share of the profits. These monopolies, along with hundreds of others equally grievous, were abolished by the Long Parliament. Duties for City improvements and other civil purposes have, however, been charged upon coal imported into London from the time of Charles II. to our own day. These rates were first imposed after the Great Fire of 1666, to assist in the rebuilding of the churches and public edifices that had been destroyed. The duties of all descriptions that had been previously laid upon coal brought into London were commuted in 1836 for a rate of 1s. 1d. per ton, which in 1851 produced a gross revenue to the City of £187,991. Eightpence per ton of this rate would have lapsed in 1862 but for the Act of 1861, which continued it in its entirety till 1872, and for the Acts 26 and 27 Vict., c. 46, by which a duty to the extent of one shilling was further continued to 1882, two-thirds being mortgaged for the Thames Embankment and one-third for the Holborn Viaduct; and 31 Vict., c. 17, which again further extended the time of its imposition to 1889, a third of the rate being under this Act applied to the freeing of certain suburban bridges and tolls. An idea of the importance and growth of the London coal-trade may be gathered from the following statistics:—At the Restoration it is calculated that about 200,000 chaldrons were annually imported into the metropolis, and in 1670 the quantity amounted to 270,000 chaldrons. At the Revolution 300,000 chaldrons were brought to London, and in 1750 the quantity was about 500,000 chaldrons, and fifty years later 900,000. In 1866 there was brought into London by sea, rail, canal, and road, no less than 6,020,182 tons of coal, yielding in duty £270,000. The quantity of coal exported from Newcastle in 1801 was 452,092 chaldrons sent coastwise, and 50,401 over sea; in 1811, 634,371 sent coastwise, and 18,054 over sea; in 1821, 692,321 sent coastwise, and 48,097 over sea; and in 1832 the number of chaldrons shipped amounted to 748,348. It must be stated that the Newcastle chaldron, by which the above quantities are estimated, is nearly equal to two chaldrons London measure. The aggregate capital employed by the coal-owners on the Tyne at the present time amounts to about £4,500,000, exclusive of the craft on the river, and the total capital employed in the coal-trade may be moderately estimated at from twenty to twenty-five millions sterling. It is calculated that upwards of 60,000 persons are directly employed in the coal-fields connected with Newcastle.

The export of lead from Newcastle, taken from the mines of Northumberland and Durham, is of great antiquity, and in the earliest records that have been preserved these mines are described as silver mines. Large quantities of lead are annually brought from the Alston Moor and Wearland mines to Newcastle for shipment, and for manufacture into sheets, shot, and red and white lead, and silver is to some extent extracted from the lead ore. Only a small quantity of iron ore was smelted on the Tyne previous to the discovery of the Cleveland ironstone, but since that time this industry has increased enormously, and about 60,000 tons of iron and 3,000 tons of steel are now annually produced there. Copper to the value of about £100,000 is also annually obtained from the copper pyrites used at the great chemical works on the Tyne. The quantity of coke yearly manufactured amounts to some 2,500,000 tons. The locomotive and engineering establishments in Newcastle and the vicinity are among the largest and the most celebrated in the kingdom, Sir William Armstrong's ordnance works at Elswick, a western suburb, being perhaps the most famous. During the past year the operative engineers of this town succeeded, after a long and determined strike, in obtaining a reduction of the hours of labour to nine hours per diem—an event that is likely to exercise a powerful and beneficial influence on the condition of the working classes generally throughout the country. Iron ship-building is carried on, as well as the building of wooden and composite vessels, upon an extensive scale on the Tyne, iron vessels reaching an aggregate of 51,236 tons having been launched in 1863. The chemical manufactures of Newcastle and the neighbourhood have grown to extraordinary dimensions since 1816. It is calculated that upwards of 100,000 tons of salt are annually decomposed in the district, for the production of crystals of soda and other mineral alkalis, while bleaching powder, vitriol, copperas, coal pitch, spirits of tar, aquafortis, glue, vinegar, soap, etc., are manufactured in large quantities. The production of window and flint glass has considerably declined during the last few years, but enormous quantities of bottles are still made at Newcastle and in its immediate neighbourhood, while impressed glass is largely made, and plate-glass to a certain extent. Earthenware also forms an important branch of industry in the town, and glass-staining has been carried to a high degree of perfection.

FARMING AND FARMING ECONOMY.—XIII.

By Professor Wrightson, Royal Agricultural College, Cirencester.

CATTLE.

INTRODUCTORY—PLACE IN ANIMAL KINGDOM—ORIGIN OF EUROPEAN CATTLE.

A CORRECT and intelligent knowledge of the British races of cattle can scarcely be attained without some insight into the position which they occupy in the animal kingdom, and their relations to allied domestic cattle found in other parts of the world. The study of the origin and development of a race of domesticated animals has many elements of interest. Sprung from a wild stock at a remote period of time, they have lost many of their natural instincts and characters, and assumed a form which can only be preserved under highly artificial conditions. They have been moulded by art, and adapted to the requirements of man, until it is difficult to realise what the form and character of the wild progenitor really was. Our cattle only exist in the domesticated condition, and although feral or escaped cattle abound as wild animals in many parts of the world, true native and perfectly wild cattle do not occur.

It is true that in Chillingham and other parks "wild cattle" are preserved, probably the direct descendants of an aboriginal forest breed. These have, however, been for many generations confined within narrow bounds, and exposed to more or less unnatural and modifying conditions. "The (Chillingham) cattle," writes Darwin, "in their instincts and habits are truly wild. They are white, with the inside of the ears reddish-brown, eyes rimmed with black, muzzles brown, hoofs black, and horns white, tipped with black." At Chartley, the seat of Earl Ferrers, a similar breed exists, and there black calves are occasionally dropped. These cattle represent *Bos primigenius*, well known as a formidable wild animal in Cæsar's time, now semi-wild, and much degenerated in size. We propose to return to this interesting subject, but in the meantime it will be well to glance at the general position of the large family of oxen (Bovidæ) in the animal kingdom, and in doing so we shall also detect the links connecting sheep with cattle in a distinct relationship.

The Bovidæ, or Oxen, are a family of the Ruminantia, a remarkably well-defined, natural order of the herbivorous Mammalia. The general characteristics of this order may be stated as follows:—All are exclusively herbivorous, and, with the exception of camels and llamas, are destitute of incisor teeth in the upper jaw; the toes, two in number, are enveloped in distinct hoofs, and many of the species have two supplementary hoofs in addition; all chew the cud, and are furnished with three or four stomachs. With the exception of the camels and musk deer, all are horned.

The order is divided into families as follows, according to the nature of the horn. (1.) The Camels and Musk Deer, without horns. (2.) The Cervidæ, or Deer, with deciduous horns. (3.) The Giraffe, constituting the family of Camelopardidæ, and characterised by possessing two frontal horns in both sexes, conical and truncated, short, covered with hairy skin, and persistent (Van der Hoeven). (4.) The Antelopes, or Antelopidæ, the first of the hollow-horned ruminants (Cavicornia of Van der Hoeven), distinguished by the persistence of their horns, which are composed of a hollow or bony core covered with a horny sheath. This family is further divided into true Antelopes, remarkable for their grace and lightness of form and agility; the Bush Antelopes, with shorter limbs and more compact form; the Capriform, or goat-like antelopes, represented in Europe by the Chamois goat; the Boviform, or ox-like antelopes, which present various degrees of likeness to oxen. (5.) The Bovidæ, or Oxen, distinguished from all the antelopes by their bulky form and great strength. It is also interesting to note at this point the position of sheep and goats, the Capridæ, which are, like oxen, connected with the antelopes by an intermediate sub-family, the Capriform Antelopes.

The Bovidæ, or Oxen, are thus described by Martin:—"In both sexes the head is armed with horns (we of course except the polled domestic breeds of cattle), and these horns consist of an external layer of corneous fibres, compacted together, and sheathing a cancellous, bony core, continued laterally from a bold occipito-frontal ridge. . . . The progressive increase of the horns is marked by successive ridges or rings at the base. . . . Their form is heavy and massive, their stature generally large; the limbs are low and strong; the haunches wide; the shoulders thick; the head large; the forehead or chaffron expanded; the muzzle (rhinarium), with certain exceptions, broad, naked, and moist; the tongue rough, with hard horny papillæ directed backwards; the neck thick, deep, compressed laterally, carried horizontally, and furnished with a pendant dewlap; the spinous processes of the anterior dorsal vertebræ (withers) are very long and stout." All the ox tribe are gregarious in their habits, and, with the exception of Australia, occur in every quarter of the globe.

This family has been divided as follows into four groups:—Cattle and Buffaloes, having thirteen pairs of ribs. Bisons and the Yak, having fourteen pairs of ribs. Besides these there is also the Musk Ox, or Ovibos (*Bos moschatus*), an animal which constitutes the genus Ovibos of Blainville and Desmar. This animal has a hairy muzzle, and short tail concealed under long hair; the horns approach each other at the base and then proceed outwards and downwards, the points turning up again nearly as in the gnu (Van der Hoeven).

In MM. Moll and Gayot's excellent work on cattle the points of difference between these groups is ably discussed. Taking them in the above order, cattle are distinguished by horny papillæ upon the tongue, by circular rings at the bases of the horns, and by the teats being arranged in the form of a square. This group includes—(1.) The common ox (*Bos taurus domesticus*) and the variety already mentioned; park or forest cattle (*B. sylvestris*) found in Britain in a semi-wild condition as above; the Zebu, or humped cattle of India (*B. Indicus*); and the white buttocked cattle (*Bœuf à fesses blanches*), (*B. bentiger*) which occupies Java and Borneo in a wild state. (2.) The Gour (*B. gaurus*) and the Gayal (*B. gavœus*), both remarkable for the development of the bony spinal processes which give rise to the withers.

The Buffalo (*B. bubalus*) is distinguished by a smooth tongue, horns triangular at the base, and teats set in the form of a trapezium. The buffalo is indigenous to Asia, and is found over a wide area. He has been largely used as an animal of draught; is completely black in hair, skin, hoofs, and horns; possesses short, thick limbs, and a massive body; forehead arched; muzzle large; horns directed outwards and backwards, and finally turning upwards towards the point; hair scattered thinly over the body, but forming tufts on the forehead, knees, and fetlocks; the dewlap is but little developed. He is useful as an animal of draught, especially in humid and fenny countries, where ordinary cattle would not thrive; as, for instance, in the Pontine Marshes. The flesh is inferior to ox-beef, and is sold at a low price in Italy. The milk is excellent. He is very fond of bathing, a partiality which is often inconvenient, as he has been known on sighting a river to rush towards it, laden with perishable goods, and plunge into its midst, there to enjoy the delights of the bath, and to sleep for hours, totally immersed with the exception of his nose.

The Bonassus, or Bison. This group comprises the European bison or auroch, and the American bison, sometimes called buffalo. The auroch is the only member of the ox tribe found wild in Europe. He is, however, exceedingly rare, and is only found in the forests of Moldavia, and in the governments of Grodno and the Caucasus, in the Russian Empire.

The bison differs from the auroch in having fifteen pairs of ribs. In other respects both the European and American species resemble each other. Both are disproportionately larger in the anterior than the posterior portions of the body, due to the great development of the spinal processes of the dorsal vertebræ, which support large masses of flesh (the bison hump) on either side. This ungainliness of form is further exaggerated by a thick coating of hair on the neck and shoulders, which is composed of two qualities. The first, long, coarse, stiff, and harsh to the touch; and underneath this a soft, fine wool, reputed finer than that of the merino sheep. The colour of the bison is blackish brown, turning in the adult male to almost black. These powerful animals have, according to M. Rafinesque, been employed in agricultural work, especially in Kentucky, and the same authority states that they cross freely with ordinary cattle, and that the hybrids are fertile among themselves, and with the two parent species.

The yak has only recently appeared in Europe. He in some respects resembles the zebu. The hump, however, of the zebu consists of fat, while the elevation of the withers in the yak is due to the elongation of the vertebral spines previously mentioned. The yak has a very short neck; horns rising vertically from his head; limbs short, light, and terminated by small hoofs. In general outline the yak more nearly approaches the horse than the ox, and he is well adapted both to draw and carry weights. He is covered with a long fleece, which, like that of the bison, is divided into two portions: an under-growth of exceedingly firm wool, which in Thibet is mixed with the soft hair of the Cashmere goat, in the fabrication of those valuable tissues for which the country is famed. The yak is invaluable in North China, Thibet, and the slopes of the Himalayan Mountains, where he figures as an animal of draught and of burden, a source of milk, of flesh, and of wool. The Imperial Acclimatisation Society introduced this useful animal into the Jardin des Plantes, at Paris, in the hope that he might become useful in mountainous districts in Europe.

Having considered with, we hope, sufficient brevity the various members of the Bovidæ domesticated by man, we must now devote ourselves to the study of common cattle (*B. taurus domesticus*). Professor Lowe enumerates nineteen breeds of British cattle. Desmarest describes fifteen French races, excluding sub-varieties and imported breeds, and MM. Moll and Gayot figure fifty-five European varieties in their "La Connaissance Général du Bœuf." The origin of these closely allied, yet evidently well marked, tribes has been traced by Nillson and Rütimeyer. Following the latter authority, we may mention *Bos primigenius*, the ancestor of some of the larger Continental races, as the Friesland and Hungarian cattle, the Pembroke in Britain, and which, no doubt, now exists in a degenerate form as the wild or semi-wild ox of Chillingham Park. Besides *Bos primigenius*, there are two other extinct species of the genus, from which our European cattle are supposed to have been descended. The first of these, *B. longifrons* or *brachyceros*, was of small size and short-legged. The Highland and some of the Welsh breeds are supposed by Professor Owen to have been descended from this species. Remains of *Bos longifrons* have been found associated with those of the elephant and rhinoceros. The last species, *B. frontosus*, existed in the same late geological period, and is believed by Nillson to have been the progenitor of the mountain cattle of Norway. This species is distinguished by a bony protuberance on the skull, between the horns. We see, therefore, that at least three distinct species of ox have been domesticated in Europe. The uniform colour of the Chillingham cattle has always been one of their best marked peculiarities. In general, the colour may be described as white, with reddish-brown inside the ears. This uniformity of colour is to be observed in several domesticated foreign breeds, and it has been ascertained that cattle which have run wild in the Ladrone and Falkland Islands have assumed a similar light or white colour, with black ears and occasionally black heads. Numerous instances might be given to show the tendency of escaped cattle to become white, with coloured ears, while in other cases a uniform dark brownish-red hue has been assumed. This general tendency has been considered to indicate the colour of at least one of the original wild prototypes of our cattle.

GREAT MANUFACTURES OF LITTLE THINGS.—VIII.

LOCKS (*continued from Page* 229).

BY CHARLES HIBBS.

The great convenience of the warded lock for ordinary purposes induced many attempts to provide it with additional features of security. We shall not pretend to notice these in chronological order, our object not being to write a history of the lock manufacture, but rather to illustrate the growth of correct principles in construction. Among other meritorious inventions, one was patented by a Wolverhampton maker, which effectually prevented the possibility of opening the lock with a skeleton key, or making a false key by taking an impression of the wards. The bitt of the key was made telescopic, and would only enter the key-hole when pushed up to its shortest length, while it would only act upon the bolt when drawn out to its longest. In the first part of its revolution it passed over a ward which gradually thickened, and so, by widening the slot, elongated the bitt sufficiently to reach the bolt, after which a fixed piece of metal, so placed that the end of the bitt rubbed against it in its rotation, acted upon it like an inclined plane, and pushed it back into its former shape.

But the inherent defects of the system were incurable. The most obvious was that the obstacles to surreptitious unlocking lay all in the small compass that was represented by the size of the bitt of the key. However ingeniously the position of the wards might be varied, or even their functions changed, as in the last example, it was not possible to produce more than a limited quantity of locks of any given size, the keys of which should materially differ from each other. The maker would soon exhaust all the variations capable of being put into so small a space, and would therefore be compelled to reproduce some, or all of them, to an indefinite extent. This was, of course, more especially the case with regard to the commoner sorts, of which perhaps tens of thousands might be made with their ward arrangements all alike. What security could be felt by the owner of a lock, however complex, if he knew that there must necessarily be others exactly like it in existence somewhere, and that any bunch of keys might happen to contain one that would unlock it? There was another radical defect in the principle, inasmuch as the *impedimenta* all lay in the way of the passage of the *key*, and there was nothing, except the downward pressure of the back spring, to hinder the passage of the bolt. Any one who could gain access to the end of the bolt could shoot it back with a moderate push. In these two essential parts of the principle lurked a fatal element of insecurity; nor was it overcome until the adoption of the tumbler system, which marked a new era in lock-making.

In this system, while the exterior shape of the lock and key was unaltered, and the action of the bitt upon the talon of the bolt remained precisely the same, the wards, the back spring, and the notches on the under side of the bolt, were all taken away. In place of them two square notches were cut on the upper side, and a tumbler, or latch, furnished with a stud that fitted them easily, was hinged at one end immediately over the bolt. This latch was of sheet metal, wide enough to hang like a curtain in front of the bolt, covering about half its surface, the stud being fastened at right angles to its upper edge. When the bolt was *half* shot, this stud was resting upon its top surface, being pressed thereon by a light spring, but when in the locking or unlocking position, the stud fell into one or other of the notches. The bolt was therefore held firmly in its place until the tumbler could be lifted and the obstruction cleared. This was effected by the bitt of the key being stepped to correspond with the depth of the overhanging tumbler, so that when it was turned round to reach the talon of the bolt, it at the same time raised the tumbler to a height sufficient to free the stud from the notch. This simple application of the principle, which we have described first for the sake of clearness, would not of itself afford much security, it being easy to contrive a false key which should effect the required movement; but the difficulty was greatly enhanced by having two or more tumblers, each hinged on a common pivot, but working with its separate stud into a separate pair of notches. The depths were also varied, so that the under edges of the tumblers, technically called their "bellies," hung at different heights, and required corresponding steps to be cut upon the bitt of the key. So far a great advance was made, but still the plan was seriously defective. The tumblers might be lifted to *any* height, and a false key need not be made with such extreme nicety as just to lift the studs out of the notches, and no more, but might be stepped at a rude guess, and, so that it lifted the tumblers high enough, would effect its object equally with the true key. To meet this, an ingenious arrangement was devised. The studs of the tumblers no longer rested on the top of the bolt, but lay in a slot cut out of its middle part, the notches being cut downwards from the slot. Had such been the whole of the arrangement, the studs could not have been lifted higher than the upper wall of the slot. But here a new element was introduced. Corresponding notches were cut *upwards*, opposite to the lower ones, so that if the tumbler were overlifted, the stud entered the upper notch, and equally prevented the passage of the bolt. The slot in the bolt thus resembled rudely the letter H, the upper and lower notches being sufficiently wide to receive the several studs lying side by side. This was a great improvement. If the workmanship were moderately accurate, no false key that was not an exact duplicate of the true one could possibly open the lock. If its steps were too low, they would not lift the studs out of the lower notches, while, if they were too high, they would certainly elevate the studs into the upper notches, and leave the bolt as fast as ever.

Although this lock was not susceptible of being picked, as the warded lock was, by a skeleton key, it was still not altogether proof against the nefarious attempts to make a false key by means of an impression taken of the interior. The bellies of the tumblers hung, as we have explained, at irregular depths, and any means by which an accurate measurement could be taken of their position would indicate exactly the number and depth of the steps to be made upon the key. A blank key, smoked, would show which of the tumblers was first touched, and this at once indicated the place where the lowest step was to be filed away; and by repeating this process until, by patient trial and filing, the shape of the false key became the exact converse of the lower edge of the hanging row of tumblers, a perfect duplicate of the true key might be made. This fraudulent expedient, too, might be materially facilitated by catching a sight of the tumblers in position through the keyhole, by means of a small mirror, thus enabling the operator to get on with his work to a certain extent before he began to take his smoked impressions, which would be only needed for the finishing strokes. It was speedily felt to be a desideratum that the bellies of the tumblers should lie all upon a plane, so as to afford no indication to the picker as to the height they required to be lifted. This was effectually done by the simple and beautiful expedient of placing the stud upon the bolt, and the slot, or gating, in the tumbler. It was not now the stud which fell into the notch, but the notch which fell upon the stud. The gating—that being the technical term—bore still the rude semblance of the letter H, but according as the legs of the letter were made longer or shorter, the tumbler fell through a greater or a lesser space. Only when the tumblers, or, as they were now sometimes called, the levers, were lifted simultaneously to the position in which the horizontal slots, or cross bars of the H, came together and formed one slot, could the stud, which projected through them all, pass from the locking to the unlocking position, or *vice versâ*. At either of those positions each of the levers fell through a different space, and of course required to be lifted accordingly by steps upon the key, although the bellies of the levers, when down, formed one unbroken surface. It will be clear that if either of the tumblers were overlifted, as would probably be the case with a false key, the lower notch would catch the stud with the same result as when the gating was in the bolt.

We must now proceed to explain the *rationale* of the immense additional security afforded by these locks, in respect of the almost infinite variety with which they can be produced; and we cannot do so better than in Mr. Chubb's own words, taken from his admirable essay. He says:—"The number of changes which may be effected on the keys of a three-inch drawer lock is $1 \times 2 \times 3 \times 4 \times 5 \times 6 = 720$, the number of combinations which may be made on the six steps of unequal lengths (on a six-tumbler lock) without altering the length of either step. The height of the shortest step is, however, capable of being reduced 20 times, and each time of being reduced the 720 combinations may be repeated; therefore, $720 \times 20 = 14{,}400$ changes. The same process, after reducing the shortest step as much as possible, may be gone through with each of the other five steps; therefore, $14{,}400 \times 6 = 86{,}400$, which is the number of changes that can be produced on the six steps. If, however, the seventh step, which throws the bolt, be taken into account, the reduction of it only ten times would give $86{,}400 \times 10 = 864{,}000$, as the number of changes on locks with the keys all of one size (that is, with one key of definite size in all save the lengths of the steps). Moreover, the drill-pins of the locks and the pipes of the keys may be easily made of three different sizes; and the number of changes will then be $864{,}000 \times 3 = 2{,}592{,}000$ as the whole series of changes which may be gone through with this key. In smaller keys, the steps of which are capable of being reduced only 10 times, and the bolt-step 10 times, the number of combinations that may be made will be $720 \times 10 \times 6 \times 5 \times 3 = 648{,}000$. On the other hand, in larger keys, the steps of which can be reduced 30 times, and the bolt-step 20 times, the total number of combinations will be $720 \times 30 \times 6 \times 20 \times 3 = 7{,}776{,}000$." Another lock-maker, Mr. Parsons, showed by a curious table that a lock with 26 levers would admit of 403,291,461,126,665,635,584,000,000 different combinations!

The reader will now see that the plain Chubb key, which has so very unpretending an appearance, as compared with one of the old-fashioned pattern, filled with mazy wards, is in reality a much greater emblem of safety. We must inform him that means are taken by all makers of repute to ensure that the permutating principle shall be carried out as a reality, and not as a sham. The difference between one lock and another is not a matter of haphazard. The keys are, as a rule, made first, and the tumblers adjusted to correspond, that being the method which is found in practice to work the best. The steps are cut by a machine, with which is connected a dividing plate, having notches in its circumference graduating in depth from the highest to the lowest of the steps that are capable of being cut on that particular sized key which the machine is constructed to operate upon. We have seen that even on a small key, not only may the relative positions of the steps be changed, but that each of them may be reduced in height twenty times; there may therefore be a great number of notches on the periphery of the dividing plate, and yet the depths of all will differ in some slight degree. On the surface of the plate, against each notch, a number is engraved, and the operator, working upon an infallible arithmetical system, is thus enabled, by reading off these numbers, to adjust the machine to a succession of combinations, none of which can be repeated until the whole series is exhausted. The notches, it will readily be apprehended, govern the action of the cutting tools, and regulate exactly the height of the steps that are being made upon the key.

Those locks were long considered to be impregnable, but we have now to recount the history of their defeat by the invincible American. The first stroke at our fancied security was made by him at the Crystal Palace in 1851, when he declared to a party of scientific men that none of the locks made in this country were proof against a properly directed assault. To prove his statement, he picked one of Chubb's patent detector locks in their presence in a few minutes. Shortly afterwards he made a sort of public challenge to the Messrs. Chubb, by notifying them that he would attempt, on the following day, to pick one of their locks which was on the door of a strong room in the City, and inviting them to be present. They did not avail themselves of the invitation, and the trial came off in the presence of eleven gentlemen of unblemished honour and integrity, who certified that Mr. Hobbs fairly picked the lock in twenty-five minutes, and locked it again in seven minutes with the same instruments. The event was much commented upon in the public press, and thus began the great lock controversy, which we must not follow for want of space.

Mr. Hobbs's dictum was as follows: "Whenever the parts of a lock which come in contact with the key are affected by any pressure applied to the bolt, or to that portion of the lock by which the bolt is withdrawn, in such a manner as to indicate the points of resistance to the withdrawal of the bolt, such a lock can be picked." This indicates the method which has been called the tentative or mechanical method, to which we have already introduced the reader in the description contained in a former article of the manner of picking the letter lock. The principle consists simply in applying pressure to the bolt in the direction tending to unlock it (if it is locked), and then feeling the tumblers very gently, one by one, until the one is discovered which is being pressed most hardly by the stud. It is scarcely within the power of human skill to make the lock so nicely as that the stud shall press equally upon all, and consequently one will be found to be fast and the others loose. The bound tumbler being lifted up very gently, a slight, very slight *give* of the bolt will tell when the unlocking slot has come into position. One of the loose tumblers will now become tight, and must be treated in the same manner, and so on, until by turns all have been got into the required position, when the lock will come open. It need scarcely be said that this is a most delicate operation with a well-made lock, and that a suitable instrument has to be used. That with which Mr. Hobbs worked was simple and ingenious. The reader understands that the only part of the bitt which acts upon the bolt is its final and longest step, the office of the other steps being merely to lift the tumblers and remove the obstructions to the bolt's passage. Mr. Hobbs then made a false key, with a single thin projection, corresponding to the thickness and height of the final step only of the true key. Its proper length of course the key-hole would give him. With this he could reach the talon of the bolt, and by turning it round, as in the act of unlocking, could get the stud to press in the direction he wanted. The false key had no bow, or cross-piece at the top, for the hand to grasp in order to turn it, but its plain stem was filed to a square at the end, to receive the eye of a lever which answered the same purpose, and which, being extended to a considerable length, admitted of a weight being hung upon it to maintain the pressure at a constant degree of tension. Thus one part of the object (the tightening of the stud against the levers) was accomplished. For the purpose of feeling and lifting the levers, a second key, also furnished with a narrow bitt, corresponding to a single step of the true key, and the stem of which was a tube throughout, was slipped on to the stem of the other key before the lever was affixed. This second key was furnished with cross-pieces which served the purpose of a bow, and could be turned round easily upon the stem of the first. The *modus operandi* is now clear. The second key was pushed forward until its bitt entered the key-hole, and with it the levers were felt and lifted cautiously, and the lock picked.

The lock of the Messrs. Chubb, which Mr. Hobbs publicly picked with the instrument described above, was furnished with their patent detector spring, which we have not yet described. It was fixed immediately over the levers, near the hinged ends, and its action was so contrived that if any one of the tumblers were overlifted ever so little, so that the stud entered the lower slot, the detector spring would seize it, and hold it there firmly, so that the bolt could not be moved either way until the spring was released. The true key would not undo the lock while the detector was on, but it would release the detector on being turned the reverse way. This was a very useful contrivance, as showing when the lock had been tampered with, and stood terribly in the way of a clumsy manipulator who was trying to pick the lock by the tentative process. We may be sure that Mr. Hobbs conducted his operations with such delicacy and precision, that he stood in no fear of the detector; he would be sure *not* to overlift the tumblers; but independently of that, his sagacity soon discovered how the detector might really be made to help him. If the position of the detector could be ascertained from the outside, which might be done by drilling, and if a piece of metal could be so inserted as to hold the detector down, the tumblers could not be overlifted, and the picking of the lock became an easy matter.

Another and more effectual defence against tentative picking was the introduction of false notches. The picker, on lifting cautiously a tight lever, felt it suddenly become relieved, and concluded that the transverse slot had been entered; when, in truth, the stud had only fallen into a slight recess, cut out of the side of the upright slot. This puzzled the picklock amazingly, as he never could make sure when he was right; and although the lock was not absolutely impregnable to him, it was practically so, owing to the time it would take to pick it.

But Mr. Hobbs himself introduced a neat little invention which met the danger in a truly scientific manner. Instead of making his stud a fixture, as in other locks—*i.e.*, riveted to the bolt, and moving rigidly along with it—he fixed it upon a small movable platform, which was let into the substance of the bolt, and turned upon a central pin. When the lock was acted upon with the true key, the stud passed freely enough from one slot into another, and did not move from its position; but when stress was brought to bear upon it, as in pressure applied for the purpose of tentative picking, the stud moved slowly round with its platform, which carried with it a dog which hooked into another part of the works, and pinned the bolt in its place.

The highest application of the tumbler principle is, perhaps, to be found in the parautoptic lock, so called from a Greek word signifying *concealed from view*, patented by Messrs. Day and Newell, of New York, and introduced to this country by Mr. Hobbs. It would be impossible to convey any idea of it by a merely written description; we must be content, therefore, to simply state its capabilities. It has the power of re-adjusting itself to any combination that its owner pleases, and to as many as he pleases. The bitt of the key, with its steps, is formed of a series of movable pieces, which the owner can re-arrange, or substitute others for, at pleasure. When once locked, which may be done with any combination, only the same combination will unlock it, and thus it may be set to a different combination each time. An impression in wax of the true key would, therefore, be of no use to the burglar, as the true key might alter its features from day to day—an advantage which was not possessed by any other tumbler lock. The machinery of the lock was necessarily complicated, and the price high, but that, where absolute safety was the object, was of no consequence.

We have now brought down our survey of lock construction to the point when another new principle comes under our consideration—that of the Bramah. We have not been governed by dates in the order of introducing the inventions here described, but have simply endeavoured to place them in such order as would assist them to illustrate each other, and convey clear ideas to the reader. The same method will be pursued in a concluding paper.

TECHNICAL DRAWING.—LXV.

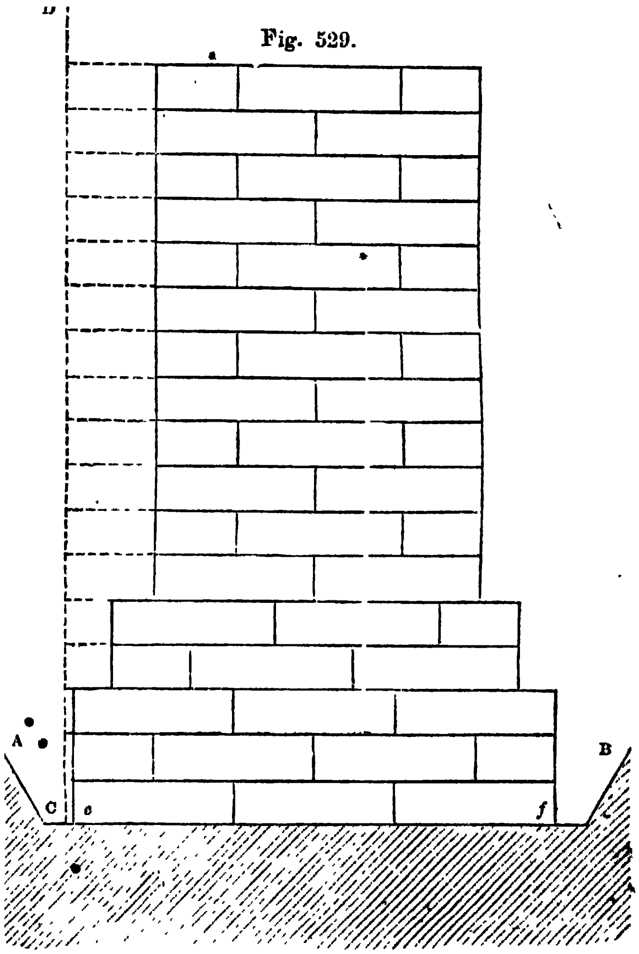
DRAWING FOR STONEMASONS.

FOOTINGS OF BRICK WALLS.

THE base of a brick wall is technically called the "footing,"* and it should always exceed the thickness of the body of the wall. The custom is to diminish the base of the wall from the bottom upwards by small steps or offsets of a quarter of a brick on each side, thus making half a brick in all saved upon each projecting course. Sometimes smaller offsets have been used, but none greater should be employed, excepting in walls of one brick thickness.

The offsets are sometimes laid out in every successive course, which in brickwork does not exceed three inches in height for each step, until the proposed diminution is obtained. Sometimes they are laid out in every second or third course, according to circumstances.

Fig. 529.



The example (Fig. 529) represents a section of a wall of two bricks in thickness, having a base of three bricks thick, which has been diminished in the manner described in the opening paragraph of this lesson.

The offsets at the base of a building are usually covered with earth, by the filling in of the original trench excavated for the foundation; but sometimes there may be offsets in a higher level, in which case there is seldom more than one externally, which is usually at a moderate distance from the ground. The others are internal.

The propriety of giving to the walls of buildings a footing such as has been described, arises from the well-known circumstance that the stability of bodies depends in a great measure upon the magnitude of their base. To add to the security of very extensive walls serving as enclosures, they are usually built not only with footings, but also with buttresses at moderate intervals apart, as may be observed in the walls of dockyards, etc. In common buildings, the several walls serve as buttresses to one another; still, footings are absolutely necessary in bad soil, and are so useful, and add so much to the stability of the structure, that they cannot with propriety be dispensed with under any circumstances, although in some cases their projection may be diminished.

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* See lessons on "Building Construction," Vol. I., page 172.

The method of drawing the example given in the preceding page is so very simple that only very few instructions will be required.

Having drawn the trench, A B, draw any perpendicular, as C D, set off on it the heights of the bricks, and draw horizontal lines from these points for the various courses of brickwork. By this plan all measuring and fraying of the paper by alterations is avoided. It will be seen that the first footings are carried up through three courses. Therefore, having marked the width of the base—viz., three bricks—draw perpendiculars at each side, *e f*, thus completing the rectangle, which forms, as it were, the first block of the footings.

The first and third courses of this block are laid alike—viz., three bricks placed so that their length passes through the entire thickness of the footing; the second course consists of two whole bricks in the interior, and one half brick in each side. These are not, however, *half* bricks, but the *ends* of whole bricks laid at right angles to the other two courses—that is, having their length parallel to the surface of the wall.

The next footing is to be drawn in the same manner, the containing rectangle being kept at a quarter of a brick within the lower block, thus leaving the present footing two and a-half bricks. These are laid so that the half (or rather the end) brick is on the one side of the wall in the first course, and on the other in the second.

The wall itself is two bricks thick, and is laid so that the courses consist alternately of two whole bricks, and one whole and two end bricks.

The student is here reminded that it is most important that brick walls should be kept perfectly vertical, for it will be evident that if a wall at the bottom is in the slightest degree "out," the evil (like every other) will go on increasing; the top will gradually extend beyond the foundation and fall. But this is not all; the wall must be kept "plumb," which term does not necessarily mean upright, but a plane surface. Thus a wall may be slanting, as a bank or side of a tower, which tapers towards the top. But in whatever position it may be, it must be kept plumb, and the plumb-rule may not only be used for this purpose, but to keep the joints over each other. This is generally termed "keeping the perpends." Now as this is so important a point in practice, it is of course necessary to be observed in drawing a wall, and therefore the joints which fall above each other should be drawn whilst the set-square is placed for any one of them, for the same line will be required in continuation in each of the alternate spaces or courses.

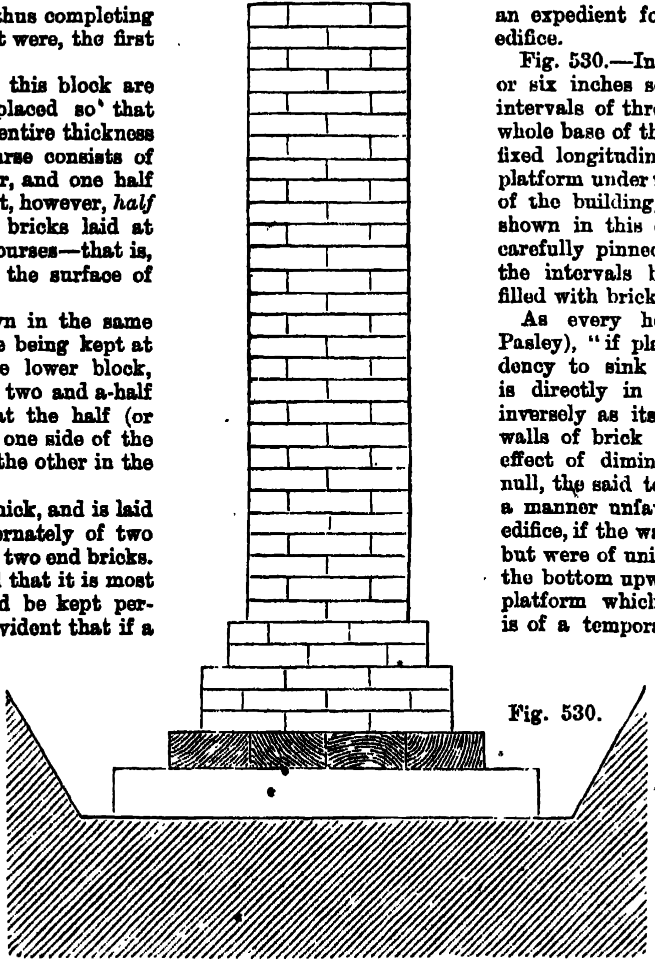


Fig. 530.

FOUNDATIONS OF BUILDINGS IN UNFAVOURABLE SOIL—PILED FOUNDATIONS.

It has been before observed that the soil upon which a building of any importance is to be erected should always be well examined before the work is commenced, which may be done by striking it to ascertain if it sounds hollow, and then by boring it in various parts with an earth-borer. Small shafts, cut at certain intervals, may also answer the purpose of discovering the nature and depth of several strata when the ground is not of uniform consistency.

is partly good and partly bad, the latter may be cut deeper until good soil is obtained, if it can be found at moderate depth, and thus the footings may be built as in irregular ground—not on one continued level, but in steps or terraces.

When the soil is all of the same quality, but looser in some parts than in others, ramming it well in the loose parts has been considered a very useful and, sometimes, a sufficient precaution; and this method of treating the soil is particularly recommended by some of the French engineers of the greatest eminence.

Even in buildings erected of bricks it has been common to commence the foundation with flat stones, placing the largest as regularly as possible, filling in the intervals with smaller ones, and ramming them down.

When the soil is of a middling quality, not absolutely good, nor yet altogether unsound and treacherous, a grating or network of continued woodwork is often used as an expedient for ensuring the stability of an edifice.

Fig. 530.—In this case, sleepers of about five or six inches square are laid transversely, at intervals of three or four feet apart, under the whole base of the intended wall. Over these are fixed longitudinal planks forming a continued platform under the whole foundation of the walls of the building, as represented in the section shown in this example. The planks must be carefully pinned down upon the sleepers, and the intervals between the latter are usually filled with bricks or stones—not with earth.

As every heavy body (says Sir Charles Pasley), "if placed upon soft soil, has a tendency to sink more or less, which tendency is directly in proportion to its weight, but inversely as its base, the footing given to the walls of brick buildings has in such soil the effect of diminishing, or altogether rendering null, the said tendency, which might operate in a manner unfavourable to the stability of the edifice, if the walls had no such increase of base, but were of uniform thickness throughout, from the bottom upwards. In respect to the wooden platform which has been described, its use is of a temporary nature, as it merely serves to prevent the brickwork, if it sinks at all, from sinking unequally whilst the mortar is yet soft, or the work green, as it is technically termed. After a certain number of years, when the mortar and bricks shall have become completely consolidated into one compact mass, they are no longer liable to separate, even if the woodwork underneath could be removed."

It will perhaps be scarcely necessary to remark that the base of every brick wall of the same height and thickness, or, in other words, of the same weight, should be greater in direct proportion to the softness of the soil on which it is built; also that the projecting parts of the footing of a wall should have a certain depth to give them solidity, otherwise the greater weight upon the central part of the base might fracture the bottom of the wall, and thereby render the footing useless; for this reason it is desirable that the offsets, when there are several, should not follow in every succeeding course, but at greater intervals apart, as already mentioned. Moreover, it is advisable in erecting a building in middling soil upon a wooden platform, such as has been described, either to make all the walls of equal thickness, and consequently of equal weight throughout; or, if that arrangement would not be convenient, to give the thicker wall the greater base in direct proportion to its weight.

In this example the wooden platform is to be drawn first, and the work is then to be proceeded with as in the former study. For illustrations of platforms laid on network of timber the student is referred to pages 47 and 56, Vol. I., of THE TECHNICAL EDUCATOR.

SILK CULTURE.—V.

By Alexander Wallace, M.D.

WILD RACES OF SILKWORMS—THE BÔMBYX YAMA-MAÏ—DISEASES OF THE WORM—ITS CULTURAL TREATMENT—THE QUALITY OF ITS SILK.

Thus far have we briefly set forth the culture of the mulberry silkworm, touching but scantily on many points which, did time and space allow, might well demand explanation in detail. We must omit almost entirely to mention those vast tracts in our colonies which, most admirably fitted by Nature to mulberry silk culture, lie waiting the time for their resources to be developed; also the special kinds of mulberry-trees, and the special races of silkworms which may there be most profitably introduced; and to supply suitable instructions for colonial sericulture, where, favoured by climatic salubrity, but devoid of artificial help, the colonist often with the rudest possible appliances brings his labour to a successful termination almost in the open air. We must pass over likewise what has been already done in Egypt, California, Chili, Turkestan, Australia, nay, even in England itself, where much might be cited in furtherance of the views held by practical sericulturists abroad of repute, viz., M. Guérin Mèneville and M. Taurigna, etc., that England is especially fitted, on account of its cool climate, for the production of healthy grain. We must omit likewise at present all reference to silk-reeling, an industry which, in the opinion of many, might easily be followed in England, not merely to the benefit of the women and children employed therein, who would thus find another opening for work afforded them—no small boon in many agricultural towns—but to the advantage also of the weaver and manufacturer, who thus might obtain at home the exact quality of silk required for their machinery, and the colonist as well, who might thus find a home market for his produce, instead of sending it, as at present, to Marseilles. Omitting these and other points of great interest, in the hope of being permitted at some future time to touch upon them, we must hurry on to dilate somewhat on the other silkworm races mentioned in our first paper, generally known as wild races, in opposition to the domesticated *Bombyx mori*, since all these found wild in their native habitats have never yet been entirely subjugated by man.

First and foremost among these, probably in point of beauty, but certainly in point of value, is the Japanese oak-feeding *Bombyx Yama-Maï*, illustrated on page 177.

What we know of the past history of this valuable race is as follows:—For many years the Japanese had cultivated an oak-feeding silkworm as well as the mulberry worm, and according to some writers the profits arising from this species exclusively belonged to the royal family; according to others, its silken produce was employed to make the rich vestments of the imperial family. In either case this valuable species was so highly esteemed that the punishment of death was by law inflicted on any one who exported the eggs. This, then, explains the reason why for so many years this species was unknown to our naturalists and its silk to our merchants. It was not till the beginning of the year 1861 that, during the presence of the French fleet in the Japanese waters, the attention of M. Duchesne de Bellecourt, French Consul-General and Chargé d'Affaires at Japan, having been directed to the beauty of the silken fabrics produced from the cocoons of the *Bombyx Yama-Maï*, he was enabled to obtain some eggs, which were transmitted to the Imperial Government of France, and finally entrusted to the hands of the Imperial Society of Acclimatisation. Now, fortunately, there is no difficulty in procuring eggs of this species in Japan, except that sometimes wooden eggs are fabricated to deceive unwary customers. The eggs first sent over

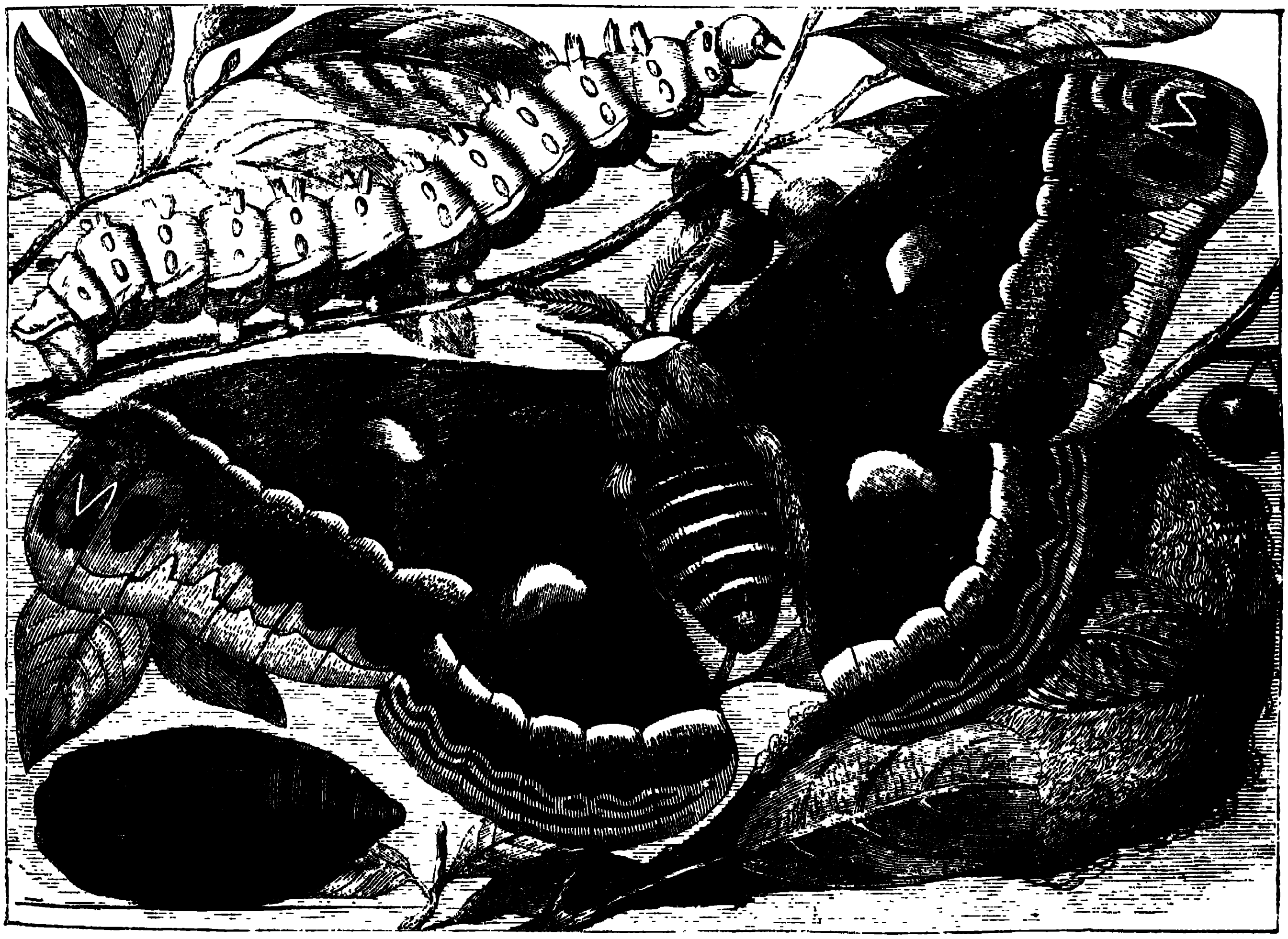


Fig. 6.—CATERPILLAR, MOTH, COCOON, AND CHRYSALIS OF BOMBYX CECROPIA.

to Europe were carefully tended in the museum at the Jardin des Plantes at Paris. Unfortunately, nothing was known of the habit of the insect, not even its food-plant; when, therefore, the first eggs hatched out, about the 15th of March, 1861, the young worms refused all the leaves presented to them, and perished. But in the beginning of April an oak (*Quercus cuspidata*) placed under glass having put out some leaves, these were eaten by the young worms, and hope was now entertained of rearing them. The President of the Society of Acclimatisation immediately obtained from Toulon and Hyères, in the south of France, young oak-leaves, with which the baby worms were fed from the 9th of April till the time when the oaks at Paris had sufficient foliage. These worms, about forty in all, grew well up to their fourth moult, but being in the serpent-house, the high temperature and close atmosphere proved injurious to them; at least it was probably from that cause that in their fifth stage all the worms (five only excepted) died off in a few days of the same sickness, a black liquid oozing through the pores of the skin. The remaining five made imperfect cocoons, but no moth hatched out. Happily a few eggs of the same batch had been sent to the learned entomologist, M. Guérin Mèneville, that he might name the species; of the few worms hatched out of those eggs one only was born sufficiently late to obtain oak-leaves. It was sent to M. Aunée, at Passy, where it throve under glass near a door which was always open. It spun a very handsome cocoon, whence a female moth emerged. This attempt, insufficient, unfortunately, to propagate the race, yet sufficed for M. Guérin Mèneville to give a name to the new insect, permitted a study of its habits, of its beauty as a larva, of the size, form, and colour of the cocoon, of the suppleness, brilliancy, and elasticity of the silken fibre, and, lastly, of the physiological and scientific character of the moth. The chance of a second experiment under such circumstances was greatly to be desired; therefore, M. Eugène Simon, the Agricultural Commissioner of the French Government in China and Japan, received a special mission to search out and send over eggs of the *Yama-Mai.* But the Japanese law, entailing death on any one detected in exporting the eggs, was for some time an insurmountable difficulty, and M. Simon was obliged to leave Japan with his mission unexecuted. But happily he had made the acquaintance of a *savant* devoted to the cause, M. Pompe van Meedervoort, medical officer in the Dutch navy, and Director of the Imperial School of Medicine at Nagasaki, who, seeing the importance of such a result, was able most fortunately to attain it. To M. Pompe van Meedervoort Europe owes the possession of this valuable species, the *Bombyx Yama-Maï.* Early in January, 1863, this *savant* returned to Holland with a parcel of eggs. The greater part of these were sent, according to a promise made to M. Simon, to the French Government, and the Government handed the eggs to the Imperial Society of Acclimatisation, and the Society to M. Guérin Mèneville for distribution among the members, etc.; some were retained by M. Pompe van Meedervoort for his friends and his country; and the remainder was given to M. Guérin Mèneville, through the kindness of a Dr. Bleeker, for distribution among those naturalists and sericulturists who were not members of the Imperial Society of Acclimatisation. Subjoined is the translation of a notice published by M. Pompe van Meedervoort, relative to the introduction of the *Yama-Maï* into Europe:—

"In 1862 I had the honour to make the acquaintance of M. Eugène Simon. He informed me of the great value of the *Bombyx Yama-Maï*, and together we made every effort, but in vain, to procure eggs of this species; we were told it was absolutely impossible to obtain them. M. Simon being obliged to return, I made him a promise before he left to continue my efforts, and, in case of success, to offer the eggs to the French Government. But the more I tried, the more I saw how difficult, if not impossible, was the attempt. I applied in vain to the Japanese merchants, the silk-growers, to many native naturalists with whom I was on friendly terms, lastly to the government, but all in vain. The reply was, 'The penalty of death is inflicted on any one who may export these eggs.' Another idea then possessed me—to apply to one of my pupils. As the Principal of the Imperial School of Medicine at Nagasaki, I was surrounded with students from the different provinces of Japan, and amongst others from the provinces of Echizen and Vigo, or Hiogo, where alone the *Yama-Maï* silkworms are reared. One of these youths, who had on several occasions given me proofs of his extraordinary devotion, was selected by me for the purpose; to him I explained the whole affair, and proposed that he should go to Vigo at my expense, in order to collect and send me as many eggs as possible. This brave young man, whose name I have promised solemnly never to divulge, started on the morrow, and after an absence of fifteen days secretly sent me the eggs, which he had collected with much difficulty and danger to himself. He told me that no one suspected the object of his journey; that was in October, 1862. My mission to Japan was finished November 1st, 1862. I started for Europe by the English mail packet, and undertook the charge of carrying these eggs to Europe. This was by no means an easy matter on board a steam-ship in the tropics. If the eggs were kept in the cabin a great risk of their premature hatching was incurred, for the temperature there in the month of November is above 95° F., and in the Red Sea 105° and more. I followed the advice of M. Simon, and placed the eggs in the ice-box on board ship, though often but little ice was therein. To this precaution is due in a great measure their safe arrival in Europe in good condition. I arrived at the Hague early in January, 1863, and at once sent out the eggs; the greater part was sent to the French Government and to the Imperial Society of Acclimatisation, according to promise I had made to my friend M. Simon."

From this beginning the new species spread over Europe. Since 1865 several trials have been made in England to rear the species, but as yet unsuccessfully. The same want of good fortune has attended many trials in France, Holland, and other countries; but several gentlemen have attained success even on a large scale. Thus M. Guérin Mèneville, at the Imperial farm at Vincennes, M. Chavannes, Professor of Zoology at the Academy of Lausanne, M. Personnat, at Laval, France, have succeeded in rearing thousands of cocoons. In 1869 the Baron de Bretton, in his woods in Moravia, raised more than 27,000 cocoons, and pursues the culture with considerable success. In 1871, in France and Germany, many thousands of cocoons were reared.

The great drawback to the cultivation of the *Yama-Maï* silkworm in this country is the prevalence of disease. I have had eggs, both sent from Japan and laid in this country, of the healthiest possible aspect; the young larvæ when born seem perfectly healthy, and thrive for a time; yet year after year I have seen the whole brood swept off in a most mysterious and hitherto unexplained manner; and my experience is similar to that of others, both here and on the Continent. From my experience I am led to think the worm is liable to three forms of disease.

First. In early life, in the first or second age, a small percentage of worms are apt to turn yellow, and be affected with diarrhœa; they become soft and die. This form of disease has been described by French writers on silkworms as the jaundice. I believe it is due entirely to want of vitality, as I have noticed that the smaller, later born, and weakly worms are chiefly affected thereby.

Second. In mid-age another malady, caused I believe entirely by too high a temperature, attacks the worms. The first indications are that the vivid beautiful green tint becomes dull and opaque, the skin tightens at the flexures of the segments, a whitish tint is now observed in patches; sometimes, but rarely, some minute dusky specks are visible at the flexures; the larvæ are flaccid, and eat but little. If muscular movement be made, as on the approach of a visitor, the skin cracks, a pale turbid green fluid issues, the worm shrinks, shrivels, and decomposes rapidly.

A third form attacks those nearly full grown or about to spin. Minute dusky specks are visible on the whole body; these rapidly increase and coalesce into brown blotches; the beautiful deep green colour turns into a muddy green-yellow, diarrhœa ensues; the larvæ cease to eat, the claspers retain their grasp; but all muscular power being lost, the body hangs an inert sack, full of decomposing fluids, which burst out at the most convenient spot. In a few brief hours nothing remains of the fine handsome larvæ but dry brown skins.

My own opinion is that shade, moisture, and a cool, even temperature, with very free ventilation, are necessary to the welfare of this creature. In its early life, in May, a temperature of 50° to 55°, or 60°, is desirable, to be increased during June to 65° to 75°; but I think a higher temperature endangers the safety of the worm; and this I believe to be the chief reason why it has been reared successfully on the Continent for several seasons, and then suddenly and entirely failed.

It is evident that the third form of disease is connected with the secretion of silk in the interior of the larvæ. We find in many cases that the worms pass the spinning-time and make no effort, others spin a little silk and then die, others when examined have no silk within them, others spin a weak cocoon and then die: either, therefore, some necessary element is deficient, or some disturbing cause prevents the formation of the silk. To this point it will be necessary for future observers to pay especial attention.

I will now mention a few points of interest connected with this silkworm. First, it differs from the *Ailanthus* silkworm, *Bombyx Cynthia*, and resembles the mulberry worm *Bombyx mori*, in passing the winter in the egg state, so that the year commences with the egg state, whereas in *Bombyx Cynthia* the perfect insect first makes its appearance in the early summer, after passing the winter in the cocoon stage. A curious circumstance connected with the egg state of this insect has been observed by M. Guérin Méneville, that the young larva is fully developed a month after deposition of the egg, and that he lies during the winter perdu within the shell, in a dormant condition, until a vernal temperature and moisture awake him to the active duties of life.

Immediately after birth the young worm, which is handsomely clothed in a yellow jacket slashed with dark velvet lines, is said to expand in volume in consequence of the air inspired, but probably also because the tubercles and spines, which were previously flattened down inside the egg, are now erect and prominent. The statement that the worm seems to grow even before it has eaten is quite correct.

The larva undergoes the same number of moults as the mulberry worm, but assumes quite a different aspect, being adorned with a beautiful vivid green tint, with blue tubercles and some silver spots on each side.

It is erratic at first, but soon settles down to its food, especially if able to obtain drink; for this peculiar larva, quite unlike the mulberry worm, requires a considerable supply of fluid. It is desirable in in-door culture to moisten the leaves twice a day. The worms put down their heads to the drops of water, eagerly imbibe them, and afterwards repose in the attitude so common to all larvæ of *Bombycidæ*, the head, fore-legs, and fore part of the body tucked in and contracted, but elevated in the air in a curve, the hind claspers firmly attached to the twig.

This larva cannot be educated on trays like the mulberry worm, but requires to rest on the twigs of the oak-boughs on which it feeds.

One great climatic difference exists between this country and Japan, viz., the rainy season, which, as we are told, generally commences about the 5th of May. I have been informed by those who have resided in Japan that about that time it rains regularly, without intermission, heavily for several weeks; this coincides with one account given by the Japanese of its culture, "that during the rain the boughs keep quite fresh." It would therefore seem that at least rainy seasons are favourable to the *Yama-Maï* larvæ, and this point is the only one which seems to me to throw any doubt on the probable success of the cultivation of the worm in Europe. Ireland would, therefore, seem to be a country specially favourable; for the same reason the north-west coast of England and Scotland, as perhaps also the south-west coast, would be specially favourable; whereas the eastern counties are probably the worst.

The cocoons of *Bombyx Yama-Maï* are of a green tint, are spun up in the oak leaves, and weigh 7 to 8 grammes each; whereas the cocoons of *Bombyx mori* weigh 2½ to 3 grammes each. The silken material is in the same proportion, viz., 70 to 80 centigrammes; that of the mulberry 25 to 35 centigrammes.

To estimate the resultant silk in weight from a given number of cocoons, it is customary to allow 12 lb. of cocoons to make 1 lb. of silk, allowing for waste, etc. The *Yama-Maï* cocoon will have a slight advantage in this over the mulberry cocoon, owing to its greater size and less waste. It is wound as easily as that of the mulberry cocoons, from end to end in a continuous thread, when placed in boiling water. There are two qualities of silk, the exterior layers of the cocoons being stouter and of a greenish-yellow tint, and the interior of a fine texture and white colour; hence the winding is divided into two operations, so as to preserve the two qualities distinct. Regarding the quality of the silk, M. Gelot pronounced the following opinion at the International Exhibition of Insects at Paris, 1865:—

"The silk of *Bombyx Yama-Maï* seems to me to occupy, after that of the mulberry worm, the highest rank. It is, perhaps, a trifle less fine, but is quite as brilliant as that silk. I believe in many cases it might be employed instead of it; and that if we succeed in acclimatising its production on a large scale, it might make up for our deficiency in the production of mulberry silk. The clear green tint which it naturally possesses is no obstacle to the various shades of dye, for it disappears with washing and becomes white. The rapid development of this valuable branch of industry cannot be too highly encouraged." Elsewhere we read: "Several bales of *Yama-Maï* silk have been purchased at Yokohama, Japan, at 550 piastres the picul (60 kilogrammes). As the piastre is equal to 6 francs, these raw silks fetch at the place of production 55 francs the kilogramme. At the same time and place were sold bales of ordinary silk at 600 to 612 piastres per picul, or 60 to 61 francs per kilogramme, about 25s. per lb."

It will be sufficiently evident, from what has already been stated, that the possession and acclimatisation of a very valuable race of silkworms in Europe is at the present time *un fait accompli*; and that although up to this time we have not succeeded in England in rearing this worm, yet we have good grounds for expectation that as a greater knowledge of its habits and of the precautions necessary to a successful cultivation are diffused, we shall find many ready to take up this new culture in Great Britain and Ireland.

CIVIL ENGINEERING.—XVII.

BY E. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES.

The necessity for enabling ships to avoid dangers from rocks, and to safely enter harbours during the night, must have been obvious to the very first men who undertook a voyage during which land was lost sight of: we may, therefore, reasonably infer that lighthouses or light-giving beacons were coeval with navigation. Moreover, it is obvious that the position of these beacons must have been well known, and would have occupied fixed positions.

We have very early and authentic accounts of structures erected by the ancients with the object stated, of most magnificent designs and dimensions. Indeed, in all the engineering works of the ancients we behold the marvellous combination of beauty, strength, and utility, which as regards the first qualification is sadly wanting in modern structures. The Pharos which stood in the centre of the breakwater guarding the entrance to the port of Ostia may justly claim a few words of notice. Its description reads almost like a fable. It consisted of four distinct storeys, of which the lower three were decorated with orders of architecture, the bottom being the Doric, the second the Ionic, and the third the Corinthian. The fourth or upper storey was surmounted by a fire, which was always lighted at the approach of night, and which, from the height of the structure, could be seen at a great distance. The building was equally convenient as a residence for the officers and men who had charge of the port. Immediately in front of this Pharos stood a colossal statue of the Emperor Claudius.

A still grander, although less architectural, beacon was erected at Alexandria upon the island of Pharos in the reign of Ptolemy. This structure was built upon a rock at the eastern extremity of the island. It was 450 feet in height, and it is stated that the fire which was kept burning at night upon its summit could be seen at a distance of 100 miles; this, however, is doubtful. The Pharos was formed of several storeys, decreasing in dimensions towards the top. The ground floor was hexagonal; the second and third storeys were of the same form; the fourth was square, with a round tower at each angle; and the fifth circular, which was continued to the top or lantern, to which a winding staircase conducted. This immense structure was built entirely of stone.

Descending to more modern periods, we may refer with some degree of pride to the many excellent lighthouses erected upon different points of our own coasts at various times, commencing about the year 1676. The whole of the beacons and "signs for the sea," as these structures were called, situated upon the English coast, were placed under the entire control of the corporation of the Trinity House by Queen Elizabeth; those in Scotland under the Commissioners for Northern Lighthouses, and those in Ireland under the superintendence of the Ballast Board. These three bodies collectively have under their supervision upwards of 200 lighthouses and floating lights.

One of the earliest erected by the Trinity Board was at Lowestoft, on the eastern coast. It is a circular tower of brick, 40 feet high and 20 feet in diameter. Its upper storey was originally glazed all round, and the light was obtained by a coal fire. This arrangement, however, was altered by the Trinity House in 1778, and a more modern and effective lantern was substituted.

The character and mode of construction of a lighthouse will differ essentially according to the position it has to occupy. It may form an efficient beacon if standing upon a projecting headland, and in no way exposed to the violence of the sea; in such a case not more than ordinary precautions need be adopted in its construction. Very different, however, will be the case when the lighthouse has to stand upon some bare isolated rock, removed many miles from any shore, and exposed to the full fury of wind and wave. Then all the skill of the engineer has to be brought into play, and every mechanical device has to be enlisted to enable the friendly beacon to retain its hold against huge mountains of water hurled at it and over it by the tempest's violence.

One of the earliest of modern lighthouses, and one of the most magnificent structures of the kind in the world, is situated at Cordouan, upon a rock at the mouth of the Garonne, the credit of it being due to Louis de Foix, a French engineer. It was commenced in 1584, and occupied twenty-six years in erection. The tower is 169 feet high from its foundations. The island rock upon which it stands is dry at low water, but entirely covered by the tide at high water. The base of the structure is a circle of 135 feet in diameter, and consists of a mass of masonry, solid, with the exception of the approach steps and the fresh-water cistern, and is carried to a height of 20 feet, terminating in a level platform, upon which the tower stands. This solid base is bounded by sloping sides, reducing the diameter of the platform to 125 feet. It is surrounded by a massive wall for protection against the violence of the surf, 12 feet 6 inches thick at the base and 11 feet at the top, and 12 feet high. The tower itself is 50 feet in diameter at the base, and consists of four storeys. These are highly decorated externally. The lowest is of the Doric order, the second of the Ionic, the third of the Corinthian, and the highest or lantern of the Composite. The original lantern was destroyed in 1727, and a new one of iron substituted. This was effected by M. Betri, who contrived a sort of iron cage or lantern formed of four pillars which supported a cupola, finished with a ball and vane. The lantern was open to admit of the free escape of the smoke from the burners. The circular ceiling was formed into a hollow funnel, the top of which was bent three feet downwards, and being covered with polished tin plates, it served as a reflecting surface for throwing the rays of light to a greater distance. This rude form of reflector became the original for the introduction of a more perfect contrivance which was introduced by M. Borda about the year 1780. His arrangement consisted of an argand lamp which was placed in front of a parabolic mirror. The mirror was formed of a sheet of copper plated with silver and burnished, having a focal length of about four inches, and a diameter of 21 inches. The form of the perfect parabola causes the rays thrown upon its surface from a point of light placed in its focus to issue in parallel lines, so that the area of the reflected beam will not exceed the area of the mirror, and hence it becomes necessary to place the burner a short distance out of the focus, whereby the rays become diverted and spread over a greater space. As a work of art, the lighthouse at Cordouan occupies a foremost position: we shall now have occasion to call attention to some other structures of the kind which, as works of engineering skill, will compare with any either of ancient or modern date.

There exists in the English Channel, in the route of thousands of ships passing and re-passing every year, a group of rocks of a stone called in Cornwall "moorstone," being either gneiss or granite. It lies nearly due south of the promontory called the Ramhead, from which—the nearest point of land—it is about ten miles distant. This group, called the "Eddystone," from the set of the tides and the violence of the eddies and currents which exist there, has always proved a source of extreme danger to shipping, being nearly submerged at high water; and it is a fact that previous to the erection of a beacon upon them, many wrecks occurred upon the rocks surrounding the Channel Islands, owing to the fear entertained by sailors of the Eddystone, which induced them to choose a more southerly course to avoid them. It is, therefore, not surprising that a very early attempt was made to fix a structure upon these rocks which should be capable of resisting the fearful violence of the storms which, coming from the west and south-west, hurled their full force upon this dangerous reef.

The first attempt to erect a lighthouse here was made in 1696 by Winstanley, who worked under the powers invested in the Corporation of the Trinity House by Queen Elizabeth. Winstanley appears to have been an amateur engineer, although certainly a man of considerable genius and capacity, and the fact that he attempted a lodgment at all upon the Eddystone, proves him to have been possessed of great courage and strength of purpose.

Winstanley's lighthouse occupied from three to four years in building. Owing to the exposed position of the rocks, and the almost continual surf which breaks over them, great difficulty and interruption was experienced in fixing the lower portion of the work. The plan adopted was to bore holes in the rock in certain positions, and to fix iron rods therein to form the main-stay for the masonry which was subsequently built around them. The whole of one summer was occupied in boring twelve holes, each 3½ inches in diameter, in a circle about 13 feet across, and securely fixing the iron rods in them. During the second summer a solid mass of masonry 14 feet in diameter, and 12 feet high from the upper surface of the sloping ledge of rock, and 17 feet high from the lower part, was built up around the twelve iron rods. During the third year the upper works were completed. The building as it then stood was 80 feet from the foundation to the vane. It is probable that the upper part of this building, which contained several storeys, was constructed of timber.

Winstanley ventured to remain in the completed lighthouse with several workmen for a considerable period during the summer of 1698, but a severe storm arose which dashed water into the building and did considerable mischief. This, however, was repaired, and a light exhibited for the first time in November of the same year. During the following year it was deemed necessary to strengthen the work; and whilst the diameter of the base was increased to 24 feet, the masonry was carried up solid to a height of nearly 20 feet. This building—which, from the print published by the architect, seems rather to have resembled a Chinese pagoda than a lighthouse—withstood the force of wind and weather for four years, and there is a well-known statement that Winstanley was so satisfied with the stability of his structure, that he expressed a desire to be in it during the fiercest storm that ever blew. He had his desire, for in November, 1703, a terrific tempest arose whilst he was at the rock superintending some repairs, and when the morning of the 27th of that month broke, nothing remained of the lighthouse or of the unfortunate inmates. The rock had been swept bare.

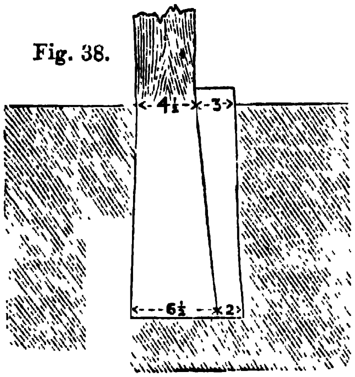
Winstanley's attempt had, however, proved the possibility of planting a structure upon the Eddystone capable of withstanding ordinary weather, and it was hoped that, by adopting greater precautions, a permanent building might be fixed there.

John Rudyerd, a London silk mercer, was in 1706 employed to re-construct the lighthouse. The extreme necessity for such a building was not long in becoming evident, for very shortly after the first structure had been swept away, a splendid ship, the *Winchelsea*, was wrecked upon the dangerous reef, and almost all on board perished.

Rudyerd was not an engineer, at least not by education; this profession did not exist as such in his time, but he formed one amongst other bold, self-taught men who have existed in almost all ages, and whose genius is only brought to the front when some necessity for its development arises.

The second building was, like the first, erected under the auspices of the Trinity House. Rudyerd was, however, not employed directly by the Brethren, but by a Captain Lovet, who under the authority of an Act of Parliament was permitted to take a lease of the intended lighthouse, with its tolls and perquisites, for ninety-nine years. Rudyerd seems carefully to have studied his subject before commencing work. He adopted the circle as the form for the plan of his building, and carried up the structure as a cone, thus selecting the form which offered the least resistance to the force of the elements from whatever quarter they burst upon it. Smeaton has left us in his narrative some interesting facts connected with Rudyerd's engineering arrangements. From him we learn the following:—A number of holes were bored or "jumped" in the rock, the formation of the holes being peculiar. The object of the designer was to cut wedge-shaped holes, the widest end of the wedge being downwards, and to insert iron bolts into these holes, keying them at the bottom so as to spread them out after their insertion, whereby it became impossible to withdraw them. This arrangement was, in fact, none other than the well-known engineering contrivance called a "lewis." The method adopted was to bore two holes 2¼ inches in diameter in a sloping direction, that is to say, they were 7½ inches apart at the surface of the rock, and 8½ inches at the bottom, the depth being about 16 inches. A third hole was bored between these vertically, and the rock between them was then cut away by suitably-shaped tools. By this means a hole of a dovetailed shape was obtained 2½ inches wide, 7½ inches broad at top, 8½ inches wide at the bottom, and 16 inches deep. The iron branches inserted into these holes were specially forged for their positions. They were 4½ inches broad at the surface of the rock, and 6½ inches broad at the bottom, so that a space was left upon one side after they were introduced into the hole of 3 inches at top and 2 inches at bottom. Fig. 38 will explain the arrangement, and will show how secure the irons must have been when so fixed. To make assurance doubly sure, however, a quantity of melted tallow was poured into each hole, and the iron and key heated to a blue heat were then inserted, and the key driven home; then, whilst the iron remained warm, a quantity of red-hot pewter was poured in, which being heavier than the tallow, drove it out. So firm and substantial was the entire arrangement, that when, many years afterwards, the irons were cut out, the iron, pewter, and tallow were found unaffected by the sea-water, which appeared never to have penetrated the holes.

Fig. 38.



After the irons were fixed, a layer of squared oak timber was laid upon the lowest level of the rock included in the plan, and of sufficient thickness to reach to the next higher level. Over this was placed another layer transversely, and over this others, every alternate layer being laid across the one next below it. In this manner a solid mass of oak was piled up, the top of which was two courses higher than the highest part of the rock, and the whole mass was securely tree-nailed together. In the centre of this timber was placed an upright mast securely fixed to the rock by strong irons, and carried up 33 feet, or more than halfway up the intended height of the building. Altogether there were thirty-six irons inserted into the rock, and in each of these seven holes, seven-eighths of an inch in diameter, were bored, through each of which a jagged bolt was passed, by which the several layers of timber were held together.

The basement of the tower consisted of two courses of solid oak, and upon these were laid five courses of Cornish moorstone, each one foot thick, the stone being held together by iron cramps without mortar or cement. The outer courses were further secured against the chance of their being lifted by the action of the sea by upright stones. Upon this 120 tons of moorstone were laid, and then two courses of timber, protected at their exposed extremities by horizontal timbers, scarfed together and bolted to the interior timbers. Up to this point the building was entirely solid. Upon this basement a well-hole was commenced to be left around the vertical mast 6 feet 9 inches square to contain the stairs, and at a point 8 feet above the highest part of the rock the step for the doorway was left. The building consisted of alternate layers of moorstone and timber up to the top of the central mast, and then a flooring of 3-inch oak plank was laid over the whole. The upper portion of the building comprised four rooms, one over the other, formed of upright timbers based upon and headed by a circle of timber to which their extremities were secured. The upright timbers were very securely connected together by tree-nails and bolts. The floor of the lantern was formed of 3-inch oak plank, and around this was the balcony.

The dimensions of the finished structure were as follows:—22 feet 8 inches diameter at bottom; 14 feet 3 inches diameter at top; the height from the circular base to the top 61 feet. The upright timbers which covered the entire exterior of the building varied in length from 10 to 20 feet, united at their extremities by scarfing and overlapping, care being taken that no two scarfs adjoined each other. The uprights were seventy-one in number, made of timber 9 inches thick at the base of the building, and 12 inches broad at the same part; but gradually diminishing towards the top in breadth and thickness. The outside seams between these uprights were caulked with oakum and pitched. The entire weight of stone employed in the building was estimated at 270 tons, and undoubtedly served as ballast in steadying the building. The doors and the shutters to the windows were composed of double plank crossed, and shut close in a rabbet to prevent the ingress of water.

That such a building should have withstood the tempest for fifty-five years is a proof of its strength, and, indeed, its career might have been much longer had it escaped destruction by fire, a calamity which happened to it in December, 1755. There can be no doubt that one of the chief errors in the construction of Rudyerd's lighthouse was the great quantity of timber employed in it, and its employment in such vital position as it occupied in the building.

The magnificent structure which was to follow will be described in our next chapter.

PHOTOGRAPHY.—IX.

By J. C. Leake.

DRY-PLATE PROCESSES: FOTHERGILL'S—COLLODIO-BROMIDE.

The collodio-albumen process described in our last article, while it may be considered as one of the most certain and reliable, is yet somewhat too complicated to become a favourite with those operators who have been used to the simple and rapid preparation of the ordinary wet collodion plates. In this article we therefore propose to describe the processes known as Fothergill's, as well as that which has received the title of collodio-bromide; both of which are more easily manipulated, and perhaps more sensitive than the collodio-albumen, although more delicate and not quite so certain in their action. The Fothergill process is one which will be found exceedingly useful to the photographer who may be constantly employing the ordinary wet collodion process, inasmuch as any good bromo-iodised collodion and the ordinary nitrate-of-silver bath will answer for the preparation of the plates, thus avoiding both the outlay and the trouble of keeping two separate sets of chemicals. The collodion for this process should not be too freshly iodised, as, in practice it has been found that an old sample not only produces better results, but that the film adheres more closely to the glass during the various washings which the plate has to undergo. A sample containing a full amount of bromide should be selected, as tending to produce greater softness, as well as helping to secure cleanliness during the development. The only solution required beyond those employed in the wet collodion process will be one of diluted albumen, prepared as follows:—Pure albumen (from fresh eggs), four ounces; distilled water, four ounces; strong ammonia, twelve minims. Mix and thoroughly beat up, as described for the collodio-albumen process. This solution must be filtered before use. After exciting the plate in the usual manner, wash carefully in filtered rain-water, or, better still, in that which has been distilled, so as to remove the whole of the free nitrate of silver. Now immerse the plate in a bath, or flood it with the following solution:—Nitrate of silver, two grains; distilled water, one ounce. If this solution be poured over the plate, allow it to remain on some minutes. The albumen solution should then be poured over the film two or three times, and the plate washed very carefully with a moderate quantity of filtered rain-water. This final washing is of the utmost importance, as upon the proper performance of this much of the success of the operation will depend. The object is to leave a sufficient trace of the albumen upon the surface of the plate, and consequently a measured quantity of water is used for this purpose, in order to ensure this result. It is difficult to state the exact quantity which should be employed for this purpose, as it seems to vary with the quality of collodion and other circumstances; but as an example, it will mostly be found that one pint will be sufficient for a plate of eight inches by six. After this washing, the back of the plates should be wiped dry with blotting-paper; and they may then be dried in a warm and dry box, of course most carefully preserved from light or dust. The average exposure will be from twice to three times that required for wet plates; and although these plates may be kept for some time both before and after exposure, by far the best results will be obtained by exposing as soon as possible after preparation, and developing within a short time after exposure. Nothing like the same latitude can be allowed in this as in the collodio-albumen process, and it could not be considered safe to keep these plates more than a fortnight before and a few days after the exposure to light in the camera. The plate after removal from the camera should be flooded with distilled water, to which has been added a small proportion of alcohol, and when the film has been thoroughly wetted the developer may be applied. For the process above described, the following will be a proper developing solution:—Pyrogallic acid, two grains; distilled water, one ounce; a few drops of alcohol may be added if required. In a few minutes the picture will begin to appear (if it should be unusually slow in development, a trace of nitrate of silver may be added to the solution), but it will be exceedingly thin. When all the details are developed wash off the solution, and proceed to intensify with the solution composed of pyrogallic and citric acids, as recommended for the ordinary wet collodion process; to which must be added nitrate-of-silver solution as required.

As we have before remarked, the intensity of negatives by dry processes must not be estimated so much by the actual density as by the colour of the deposit, and hence over-development must be most carefully avoided. In this, as in the collodio-albumen process, the hyposulphite-of-soda solution will be the proper fixing agent.

A somewhat important modification of this process has recently been introduced with considerable success by Dr. Ryley. In this the plate, after having been sensitised and thoroughly washed as before described, is coated with the following albumen solution:—Albumen, two ounces; water, four ounces; ammonia, one drachm. This solution to be well mixed as above described, and filtered before use. Allow this to thoroughly soak into the film, thoroughly wash the plate with distilled water, and dry. When perfectly dry moisten with distilled water, and cover with the following solution:—Gallic acid, four grains; distilled water, two ounces. Filter before use. Allow this solution to thoroughly soak into the film, and dry without washing off the gallic acid. Plates thus prepared will retain their sensitiveness for five or six months, and they are particularly clean and free from stains and markings. It is necessary, however, to be particularly careful to remove the whole of the nitrate of silver after the sensitising process. The development may be conducted precisely as in the ordinary Fothergill process before mentioned.

The next process of which we shall have to treat is one which will tax the care and manipulative skill of the operator to a considerable extent, and which should therefore not be attempted until he has acquired considerable experience in other and less delicate and complicated work. The process to which we refer is termed by its inventors, Messrs. Sayce and Bolton, the collodio-bromide; and one of its chief peculiarities is that it dispenses with the nitrate-of-silver bath common to all other methods of preparing a sensitive surface by means of a collodion film, the collodion in this case itself containing the sensitive salt. The collodion suitable for this process is composed as follows:—Pyroxyline (gun-cotton), six grains; ether and alcohol, of each, half an ounce; bromide of cadmium, six grains; bromide of ammonium, two grains. Dissolve the salts in the alcohol, mix with the ether, and add the pyroxyline, until dissolved. This collodion may be mixed in any quantity, as it will keep an indefinite time, but it should be allowed to stand at least a week before use. In order to render this collodion sensitive, nitrate of silver must be added to it in the proportion of from eleven to thirteen grains to the ounce of fluid; the smaller quantity being the safest, and the larger producing the most sensitive film. The nitrate of silver must be ground to the utmost degree of fineness in a glass mortar, and be added by degrees to the collodion in the proportions above given, with constant agitation, in order to ensure perfect combination. Of course this mixing must be effected in non-actinic light, as the compound is exceedingly sensitive to light; in fact, it must be treated precisely as a sensitised wet collodion film in this respect, the smallest ray of light being sufficient to spoil it. After resting a few hours the sensitive mixture will be ready for use. The plate may now be coated exactly as in the wet collodion process; although it may be at times advisable to coat the edges of the glass for about a quarter of an inch over their surface with a solution of india-rubber in benzole, in order to prevent the slipping of the film. When coated allow the collodion to become thoroughly set (much more so than in the ordinary wet process, when a bath is employed), and wash in a dish of water until the greasiness upon the surface disappears, and the water flows freely over the film. The plate will now be ready for the final immersion in a solution prepared as follows:—Dissolve in four ounces of hot water twelve grains of gallic acid, forty grains of tannin, and twenty grains of grape-sugar; and when cold one drachm of alcohol. This solution may be used almost indefinitely. Into this solution immerse the coated plate, and allow it to remain three or four minutes; upon removal drain thoroughly, and dry as in the ordinary process, when it will be ready for exposure in the camera. The time usually recommended for exposure is three times that required for a wet plate, but the writer has found that plates prepared with a full quantity of silver will not, under favourable conditions, require more than twice the exposure necessary for ordinary collodion work; and it should be remembered that the powerful developing agent proper for use with these plates will often enable the operator to bring out an image even when the exposure has been slightly shortened. The proper developing agent for collodio-bromide plates is one of comparatively recent introduction, and is known as the alkaline pyro-developer.

In the preparation of this developer it is advisable to make up stock solutions in three separate bottles, as follow:—No. 1 should consist of pyrogallic acid, one and a-half drachms; absolute alcohol, one ounce. No. 2, carbonate of ammonia, one and a-half drachms; water, one ounce. No. 3, bromide of potassium, ten grains; water, one ounce. When required for use, mix solution No. 1, ten minims; solution No. 3, five minims; water, one ounce; and pour them over the wetted plate. After remaining upon the surface about half a minute, pour this solution back into the developing-glass, and add four or five drops of the carbonate-of-ammonia solution, and apply the mixture to the plate again. In all probability the developing will commence almost instantly, and should it appear too rapid the action must be checked by the addition of a few drops more of the bromide solution. Should the development be tardy from under-exposure or other causes, more of the pyrogallic solution must be employed, leaving the bromide out altogether. With careful and judicious treatment, the development will not take much longer than is required for wet plates, but it is better to work slowly than to hurry the process in the least degree. It sometimes happens that plates develop well, but with little intensity. In this case it is better to wash off the alkaline developer, and complete the intensification with ordinary pyrogallic acid and silver, as in the wet process. It must here be explained that in the compound developer given above the chief reducing agent is the pyrogallic acid, the action of which is considerably intensified by the addition of the carbonate of ammonia. The bromide of potassium is simply a restraining agent, employed to keep the other chemicals in something like order; in fact, it plays the same part as acetic or citric acids in the ordinary processes, and the addition of too much of it will not only restrain the action of the pyrogallic acid, but altogether destroy it, and prevent any development from taking place. When sufficient density has been obtained, the plate may be fixed in the usual way; but it has been advised that cyanide of potassium be used instead of the hyposulphite of soda, on account of the latter causing an increased tendency on the part of the film to leave the glass upon which it is supported.

In concluding this part of our subject, we may here recapitulate some of the most important points which must be observed if the highest success be desired in dry-plate work. In the first place, the glass plates used must be of good quality, and most perfectly cleaned; in the wet process this is important, but much more so in the dry. In the former case the film in its sensitive condition is only in contact with the glass for a comparatively short period, while in the latter it may be for days or weeks. This, of course, gives full scope for any deleterious action which may be set up, and the result is dirty and spoiled plates, many failures, and much disappointment. Besides being quite clean, however, the plates should be perfectly dry, or there will be a greater tendency to splitting and tearing up of the film during the washings which it will have to undergo. When coating the plate, allow the collodion to become well set before immersion in the nitrate bath, or the same tendency will be manifested. Be sure to keep the nitrate bath up to its full strength, and always test it with a wet plate to ascertain that it is in good working order before preparing a batch of dry plates. Allow full exposure in the camera, as a little over-exposure can be remedied, but under-exposure never. Before proceeding to develop a plate, varnish the film about a quarter of an inch round the margin; this will prevent the water getting under it and breaking it up. Wash well after fixing, or the hyposulphite will destroy the negative; above all things, be careful in the water used for washing plates before exposure, as many failures may be traced to the employment of that which is impure. It is for this reason that we have advised the use of distilled water in many cases when ordinary water is usually recommended. Finally, the utmost care and cleanliness must be observed, especially in the dishes and vessels employed for washing the sensitive plates.

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SEATS OF INDUSTRY.—XXVI.

NEWCASTLE-UPON-TYNE (*continued*).

BY WILLIAM WATT WEBSTER.

To continue our account of this town, within the past few years the making of fire-bricks has attained gigantic proportions, about eighty millions being manufactured yearly in the district; and gas retorts and sewage pipes are produced in large quantities, and sent to all parts of the world. Grindstones from the Newcastle quarries are made at the rate of about 100,000 per annum, and Portland and other cements are manufactured to the extent of some 11,000 tons. There are several large paper works of high reputation, and several large tanneries in the vicinity of Newcastle. Between five and six hundred dozen hats and caps are weekly produced in the hat factories of the town, which employ an aggregate of about 500 persons; and coach-building has in recent years become an important trade. Besides those we have enumerated, a large variety of minor industries are actively prosecuted in and about Newcastle. The trade of the port consists chiefly of coal, and articles for the manufacture of which coal is largely required. Including North Shields and South Shields, which may be considered sub-ports of Newcastle, more vessels are owned on the Tyne than belong to any single port in Great Britain, Liverpool and London excepted.

Newcastle is situated on the north bank of the Tyne, and is 9½ miles from its mouth, 54 miles east of Carlisle, 244 miles from London by road, and 275 by the Great Northern Railway. It stands partly on an elevated terrace, and partly on ground that slopes towards the river. The pits from which the coal is obtained lie within about two miles of the Tyne, and extend from within two miles of its mouth for sixteen or eighteen miles up the river. There are upwards of fifty large collieries at work within eight miles of the town. During the past fifty or sixty years very extensive improvements have been made in the streets and houses of Newcastle, and it is now one of the handsomest towns in England. Formerly a large proportion of the houses were constructed of timber, with the upper storeys projecting over the lower, and quaint gables and dormer windows, and at a later date they were built of brick; but all the modern streets are lined with houses of stone, which is found in abundance in the neighbourhood. It was principally through the exertions and public spirit of an enterprising citizen, named Richard Grainger, that this change was effected; but an extensive conflagration that took place in 1854 also indirectly contributed to the improvement of the town. Many of the streets, squares, and public edifices possess great architectural beauty, and the town is excellently lighted and paved. The water-supply, which is abundant and of good quality, is derived from streams and small rivers to the north-west of the town. The railway viaduct, or High Level Bridge of Newcastle, is one of the engineering triumphs of Robert Stephenson. This gigantic work is 1,337 feet in length, and its height above the water-mark is 112 feet. It consists of four river and two land arches of cast iron, supported on piers of masonry; and below the railway there is a carriage road for ordinary traffic 35 feet wide. The entire structure cost £491,153, and was opened by Queen Victoria in 1849. All the railways entering the town stop at a large station near its centre, and nearly seventy trains arrive and depart daily. The market for the sale of butchers' meat and vegetables, constructed by Robert Grainger, is 310 feet in length, has an area of 9,050 yards, is lined with 243 shops, besides stalls, and is entered by 14 doors. It is one of the most spacious and convenient public markets in the kingdom. A bi-weekly corn, and a weekly hay, produce, and cattle market are held in Newcastle, and both are of considerable commercial importance. During the year 1862, 54,936 fat cattle, 286,110 sheep and lambs, and 34,544 swine were sold in the cattle market. The Newcastle News Room is one of the finest in Great Britain; and the theatre, situated in Grey Street, the handsomest thoroughfare in the town, is an elegant building, designed after the Pantheon at Rome. There are thirteen churches and chapels connected with the Established Church in Newcastle, and about twenty-eight places of worship belonging to other denominations. The most ancient and interesting ecclesiastical edifices are the church of St. Nicholas—originally founded in 1091 by Osmond, Bishop of Salisbury, and placed under the jurisdiction of the Bishop of Carlisle—which was burned in 1210, the present structure having been finished in 1359; and St. Andrew's Church, said to have been built by David, King of Scotland, partly Norman in style, with a large but low embattled tower. Among the educational and literary institutions of the town, the most noteworthy are the Free Grammar School; the School of Medicine and Surgery, the lectures at which qualify for the diploma of the London College of Surgeons and the licence of the Apothecaries' Company; and the Literary and Philosophical Society, established in 1693, which occupies a handsome Doric building, and possesses a museum and a library. The principal monuments in Newcastle are a column, surmounted by a statue of Earl Grey, erected in commemoration of the passing of the Reform Bill of 1832; and a bronze statue of George Stephenson.

During the present century the population of Newcastle has increased at nearly the same rate as other English towns. In 1801 there were in the borough 28,366 inhabitants: in 1811 the number declined to 27,587; in 1821 it rose to 35,181; in 1831 it was 42,760; in 1841, 69,430; in 1851, 87,784; in 1861, 109,108; and in 1871, 128,164. Although in a different county, and under a separate jurisdiction, Gateshead, on the opposite bank of the Tyne, must be considered as a suburb of Newcastle. The population of Gateshead ought, therefore, to be added to that of Newcastle, and in 1851 there were in Gateshead 25,568 inhabitants, making a total population for Newcastle, plus Gateshead, in that year of 113,352. In 1861 the population of Gateshead was 33,587, which, with the population of Newcastle, makes a total of 142,695; and in 1871 it was 48,592, giving in the same way an aggregate population of 176,756. The electoral limits of Newcastle were enlarged under the Boundary Act so as to include, with the old borough, the townships of Jesmond, Heaton, Byker, Elswick, and Westgate. Newcastle was divided by the Municipal Act into 7 wards, and is governed by a mayor, 13 other aldermen, and 42 councillors, and has a commission of the peace under a recorder. The town has the privileges of a county, and it is represented in the House of Commons by two members. Among the eminent natives of Newcastle are numbered Duns Scotus; Mark Akenside, the poet; Hutton, the mathematician; Lord Eldon, the celebrated Lord Chancellor; his hardly less celebrated brother, Lord Stowell; and Admiral Collingwood. Intimately connected with the town, though not born there, were Thomas Bewick, the famous wood engraver; Robert Morrison, the Chinese scholar; and George and Robert Stephenson, the engineers.

SANITARY ENGINEERING—XIX.

CLOSETS AND TRAPS.

In our last paper we gave some detailed information as to the saving of water by means of flushing cisterns, and also alluded to the necessity of providing ventilation for systems of pipes. We now approach a branch of the subject which, although it may not be considered pleasant by the general reader, is perhaps, considered from a strictly sanitary point of view, superior in importance to any that have preceded it, as we now come in contact for the first time with a matter which has recently occupied no small share of public attention—namely, sewage gases; and before entering upon the mechanical details, it may be as well to show to a certain extent the nature of the dangers to be apprehended and the difficulties to be overcome.

Sanitary engineering, as far as this particular branch of it is concerned, may be dated as commencing within a century. Previous to that date the old cesspool system was almost alone in operation, and although probably, or indeed certainly, the various complaints arising from imperfect hygiene were as widely spread and as deadly in their effects, public scientific attention had not been awakened, and the information now at our command was not available. And here let us note that it is by no means the most offensive gases that are the most deadly. As an extreme instance, we may quote a case which occurred in the western part of London some years ago, when on entering a large section of a public sewer which had been hermetically closed for some time and out of use, and through which no current either of water or air had passed, some of the party were actually and instantly stifled by the deadly vapour. Others who escaped with difficulty described the only warning of danger they received as something like a faint smell of rotten cheese.

Again, in another form, in a house recently erected in the north of London, three successive families who occupied it lost almost immediately several of their members by typhoid fever, although there was no such distinct intimation of the presence of defective drainage arrangements at any time as would be sufficient to attract attention. This we may take for granted, as otherwise the house would not have been entered by fresh tenants at comparatively short intervals of time without some investigation being made. Ultimately the case was taken up by the local sanitary authorities, when it was discovered that beneath the surface of the basement was a bed of partially decayed vegetable and sewage matter, from which this sewer poison arose, though its presence was not so patent as to be detected by any ordinary occupant. Quoting from a pamphlet by Dr. Alfred Carpenter on this subject, he says:—"It was not until the general introduction into towns of closets and pipe-sewers that the injury produced by the gas was sufficiently isolated to be positively identified. The result of the introduction of closets within the walls of our houses casts a reflection which is not altogether deserved, and which need not necessarily be borne. This mischief has arisen from a neglect of a natural law—viz., not providing for exits as well as for entrance, sewers not being, like soda-water bottles, sufficiently impermeable as to allow of being charged with gas under pressure."

In succeeding practical illustrations we shall more than once have occasion to refer to this axiom, as we may term it. In the early sanitary works which were carried out under the authority of the Public Health Act of 1848, the consequences of sewer gas not being foreseen, were not provided against. No provisions were made to prevent its ascent into the house or exit into the open air before it could reach the inside of the dwelling. "As a factor in the production of typhoid fever its power is now well known; many other disorders of the system have been directly traced to its influence, diarrhœa, dyspepsia in all its forms, various forms of asthma, and headaches constant and intermittent."

The same author also quotes a very telling case of ill-considered trapping. When the Warehousemen and Clerks' Schools at Russell Hill were first opened the children were in the enjoyment of good health, but in the autumn of 1867 typhoid fever made its appearance. It seems that a smell at first slight, but afterwards intense, had been perceived in the laundry. The place of exit was trapped, and the smell prevented at that place from the sewage gas until it reached the interior of the building. The consequence was that it was conveyed from the cesspool by the pipe-sewers into the lower part of the building, and then into the other rooms. The arrangements for general ventilation being deficient, and many of the rooms heated by hot water, so that there were no open fires, an accumulation of sewer gas frequently took place during the night, and the children entering the rooms before breakfast were exposed to its influence under the most unfavourable circumstances, the result being that 40 per cent. suffered from forms of typhoid fever, which was, however, fortunately of a mild type.

Instances might be multiplied almost indefinitely showing the deleterious effects of sewer gas. The last two we have quoted show how in positions where such a result might be considered quite unexpected, its evils were experienced, and we must leave untouched the vast question connected with the crowded dwellings of the poorer classes, where in many parts of London and our larger provincial towns, sanitary arrangements, though much improved of late years, are still lamentably defective.

Having thus briefly indicated the direction in which precautions have to be taken, we now proceed to the mechanical part of the question, merely premising that each example selected is only one of a class. The number of appliances patented within the last twenty years may probably be reckoned by hundreds, some entirely novel, some merely adaptations; and we commence with the general statement that in all closets treated in the present paper the water-lute or hydraulic seal is the principle adopted. With earth-closets and other methods of sewage disposal, in which different methods are employed, we propose to deal at length in future articles. The general principle of the water-lute is that a body of water shall always be maintained at the topmost part of any system of sewage delivery, so that no free air-passage for gas is left open. The simplest form for illustration of the principle is the old-fashioned brick trap with a dipstone, as in Fig. 14, applied in an ordinary drain.

We give this illustration at this point to show the simplest possible arrangement for the passage of sewage and water and the exclusion of air in the course of an ordinary drain, assisted by flushing, and the necessary currents to which drains should always be laid. It will be seen that the "dipstone" has its lower edge always in the water, thus stopping all passage of air; but there is this remark to be made, that a "*double trap*," as it is technically called, is invariably a source of failure and discomfort. Supposing by some blunder two of these traps constructed in one drain within a few feet of each other, the gas contained in the intermediate portion of the drain immediately becomes "water-bound," and instead of passing away through the second trap, this acts as a check upon the air or gas, whichever may happen to fill the space, and although the sewage or water may run off, the gas confined between the two traps, instead of passing off through the *second*, will bubble up through the *first*, unless (and here we may refer to our last paper on the ventilation of pipes) an *exit* to the external air is provided, either in the shape of an air-pipe or by some other means. We give this illustration in the plainest form, as it embodies the one leading principle of all closets or traps where water is used, however complicated in their appliances or expensive in their fittings—to provide an efficient hydraulic lute or water-seal, and avoid all chance of "*back* pressure," whether arising from double-trapping or tidal influences, a most important point for consideration in low-lying districts, such as Bermondsey, or water-side localities, such as Scarborough.

The plain general principle thus stated, we arrive at the first portion of the subject proper of our paper, "Closets," and proceed to give a few illustrations of the appliances now in general use, with a few words of explanation as to each. The great improvements in what may be called sanitary pottery have placed us very far in advance of the last generation in this respect. Our first (Fig. 15) is a plain cottage trap, dependent upon simple flushing, without any mechanical contrivances. This is made of plain earthenware.

Our next illustrations (Figs. 16, 17) show the action of one of the most recent improvements in earthenware. It will be seen that the valve, closet, and trap are manufactured in one piece of earthenware. The manufacturer is Mr. George Jennings, of Lambeth.

We now pass to various descriptions of closets where the basin only is in china and earthenware, and other portions of fittings in metal. Fig. 18 is what is ordinarily described as a *pan* closet. Within the receiver A (Fig. 18) is contained the hinged pan B (Fig. 19), and the water-line, when shut, is indicated as before.

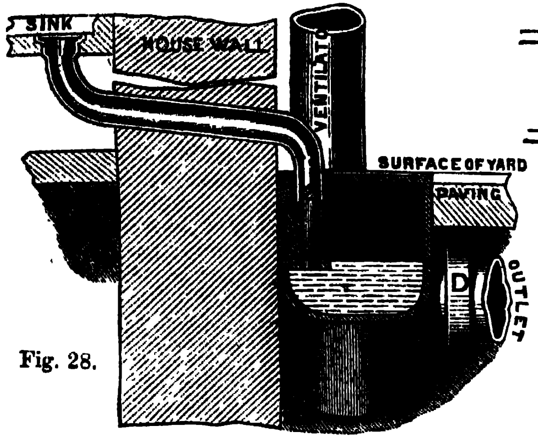


Fig. 28.

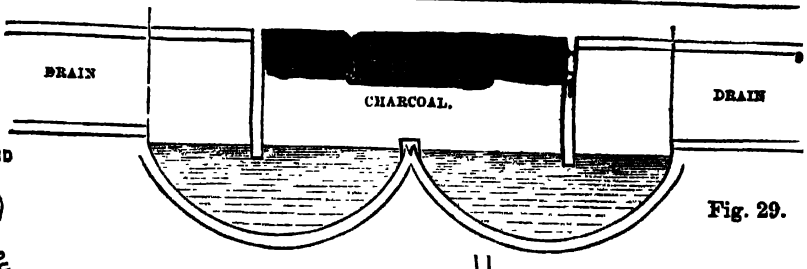


Fig. 29.

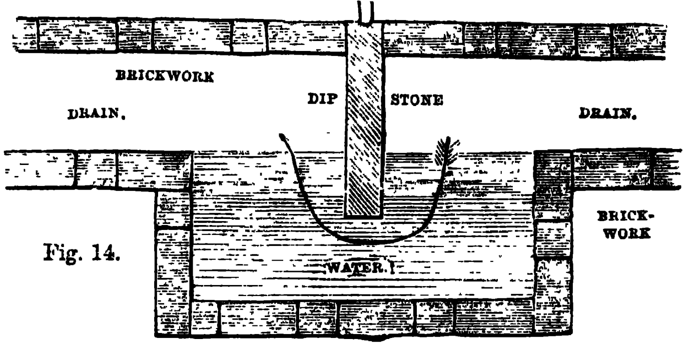


Fig. 14.

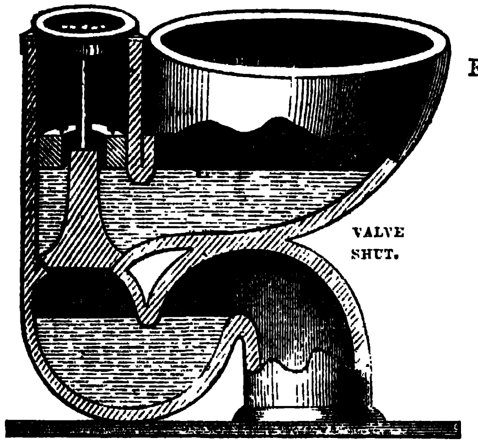


Fig. 16.

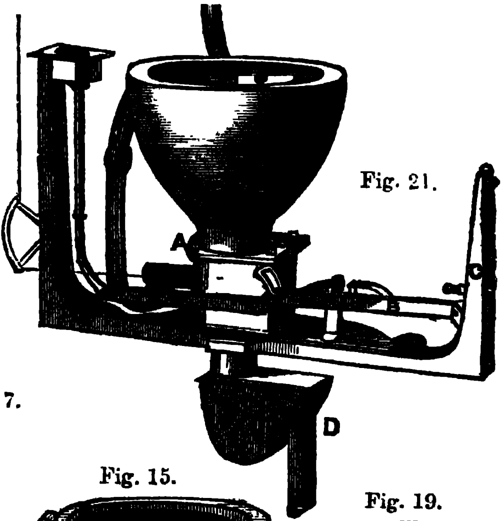


Fig. 21.

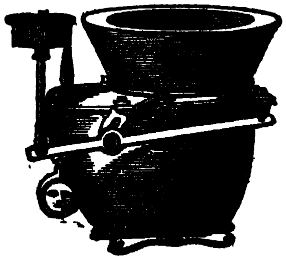


Fig. 18.

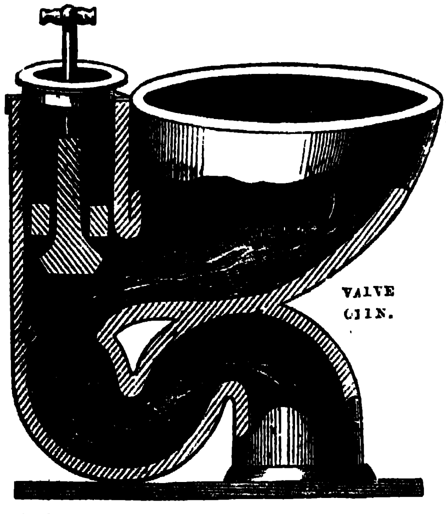
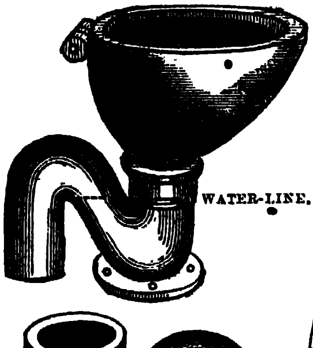


Fig. 17.

Fig. 15.



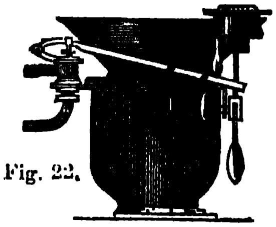
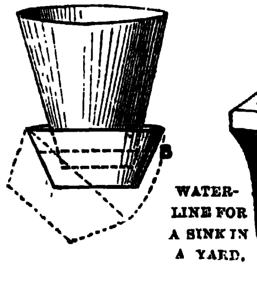


Fig. 22.

Fig. 19.



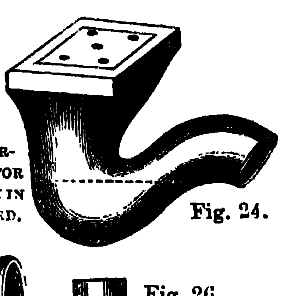


Fig. 24.

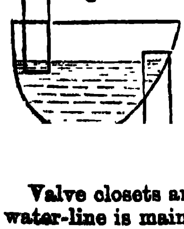


Fig. 20.

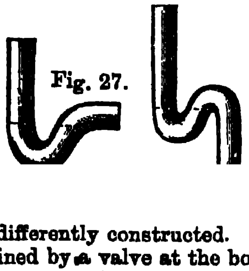


Fig. 27.

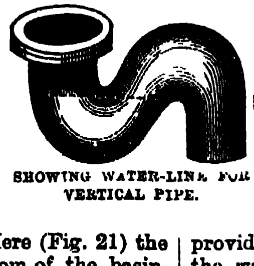


Fig. 25.

SHOWING WATER-LINE FOR VERTICAL PIPE.

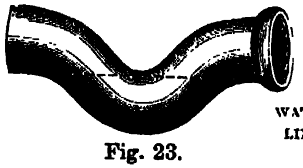


Fig. 23.

SHOWING WATER-LINE FOR HORIZONTAL PIPE.

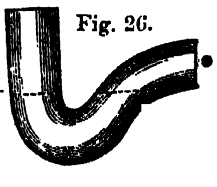


Fig. 26.

Valve closets are differently constructed. Here (Fig. 21) the water-line is maintained by a valve at the bottom of the basin, carefully ground in or maintained in its place, or hermetically sealed by a lever and spring. The valve is at A, B is the lever, and C is the spring. In this case the additional security of what is technically called a D-trap is shown at D; this is made of lead, and its internal construction and water-line are shown in the outline sketch in Fig. 20.

Fig. 22 shows a closet known as Underhay's Patent, which provides a bellows arrangement for the gradual delivery of the water, indicated at A. These closets are often provided with elastic or india-rubber valves, and there are many mechanical details of construction introduced, upon which a volume might be written; but with this last instance we dismiss the question of closets, and proceed to that of traps, of which we shall also give some sketches, showing two or three of the most important improvements recently introduced.

We have now passed the points of construction at which water-supply and ventilation only are to be dealt with, and have arrived at that period in our papers on "Sanitary Engineering" at which it is to be taken for granted that all air to be dealt with is *foul*, that is to say, charged in a greater or less degree with sewage gases; and the *raison d'être* of *traps*, is to provide a vessel through which, in whatever form it may be constructed, sewage elements may pass if contained in a volume of water, without allowing any air to return by the passage. And here arises a question as to the comparative *size* of pipes and drains. When the subject was, as we may say, in its infancy and little understood, the idea was started that by having the minimum size both of pipe and drain, sewage elements could be forced downwards with their attendant gases, and the whole bodily discharged into the ultimate receptacle, whatever that might be; and at that time it was not uncommon to hear of conveying the whole drainage of a household through a 3-inch pipe. The error in the first place was in the theory, as these gases can never be forced downwards, the effect of any pressure slightly exceeding that of the ordinary atmosphere being sufficient to return them through all the ordinary traps and water-lutes, and to raise them to the surface in bubbles; and in the second place, mechanical, as the accompaniments of ordinary kitchen washings, sewage being left out of the question, were sufficient, by their gradual accumulation of solid matter, grease, or otherwise, to create an absolute stoppage. We quote from a well-known publication:—"In the 'Menzies' system it is supposed that by having pipes only of sufficient size to carry the sewage matter, gases will have no room to form, or be forced downwards. Unfortunately the facts are otherwise. For the pipes often choke at Aldershot, where this system is in operation, and the *matter* (*sic*) bubbles up, entailing a cost of several hundred pounds annually to open and repair them, in effecting which it is impossible to avoid danger from letting loose some of the gas."

A pipe of ample size, well flushed and thoroughly ventilated, has been proved by experience to be the only efficient medium for removing sewage. Into the detail, construction, and manufacture of the various descriptions of pipes we do not here enter, as under another heading in the series of THE TECHNICAL EDUCATOR these questions will be dealt with at length. We content ourselves with giving a few sketches (Figs. 23, 24, 25), showing the various methods of trapping stoneware drains, marking the water-line in each case. It will be seen that in every case the only protection is the water-lute or hydraulic seal to prevent the passage of foul air.

The D-trap, of which an outline sketch is given in Fig. 20, and which in a slightly modified form is also called a P-trap, was for many years the only form of trap available in plumbers' work. Where size is required, it is made of pieces of lead soldered together, into which the inlet and outlet pipes are secured by similar means. A new form of trap has, however, been introduced within the last few years by Messrs. Board and Dent, and is the subject of a patent. The trap can be cast in one piece of lead to any size, as may be seen in the sketch, and presents many advantages. There is much less room for the accumulation of sediment, offensive or otherwise, and the absence of joints is a great safeguard against leakage or failure from any similar cause. We subjoin two sketches (Figs. 26, 27) showing the form of trap and the water-line. It will be seen that though the material is different, the principle is identical.

The difficulty overcome, and therefore the secret discovered and made the subject of the patent, was the removal of what is technically called in casting the "core," *i.e.*, the inside of the mould; an ingenious mathematical combination of pieces which we can only compare to a puzzle, and which no diagram could make intelligible, attains the desired effect. The same firm have applied these traps to closets, with various improved valves, india-rubber and otherwise; but having already given some general ideas of that subject, we have no space for further detail.

The last modern improvement is the introduction of ventilating traps, which, while they intercept the passage upwards of foul air from the drains, provide also for its dispersion to the external air *outside* the walls of the house.

We give a section of one, Mansergh's patent (Fig. 28), applied to a sink only; but it will be readily seen how it is also applicable to the *release* of foul air from any system of drainage. Another recently introduced is the invention of Mr. Cottam, an Associate of the Institution of Civil Engineers. It consists of what may be called a twofold trap (Fig. 29), with an exit to the open air in the centre, provided with a body of charcoal as a disinfectant to the gas involved. In giving this we are to a certain extent touching upon the subject of subsequent papers—the disinfection of sewage gases; but as perhaps the most novel effluvium interceptor, as it is termed, which has been introduced, we conclude at this point the subject of closets and traps, one of the most important (as will appear from the cases cited at the commencement of this paper) of all that fall within the province of the engineer.

BUILDERS' QUANTITIES AND MEASUREMENTS.—X.

BY E. WYNDHAM TARN, M.A.

JOINERY AND IRONMONGERY (*continued*).

IN the last lesson we explained at length the methods adopted in measuring the various works which are executed by the joiner in the erection and finishing of buildings. We now proceed to show by examples how those rules are to be put into practice by the measuring surveyor, either in taking out quantities from plans, or in measuring work actually executed. In practice it is advisable to enter the works on each floor separately in the dimension book, so that they can more readily be referred to afterwards, if any question should arise as to the correctness of the measurements. The measurer is also less likely to miss any part of the work by completing each floor before he proceeds to the next. The staircases may be left to the last, unless they differ at each flight, when they may be taken at the same time as the work on the floor to which they belong is measured.

TWO-PAIR FLOOR.

	15 0 12 6	187 6	2 cut w. batten folding floor.
2)	4 6 0 9	6 9	Add recesses.
	6 6 3 6	22 9	Add landing.
		217 0	
	44 0 0 7	25 8	1 in. sqre. skirting.
	3 6 4 6	15 9	Dl. cased frame, o. sk. sill, 1½ in. ov. sash, dble. hg., br. pulleys, white lines, i. wts.

No. 1 brass sash fastening.

13 6 0 5	5 8	¾ in. framed grounds.
14 0	14 0	1 in. archve. mo., 2¼″ wide.
4 6	4 6	1 in. window nosing.
6 6 2 9	17 11	1½ in. deal square 4 p. door.

No. 1 pair 3 in. b. and s.
„ 1 2-bolt i. rim lock, and b. furn.

15 2 0 5	6 4	1½ in rebd. and bdd. linings.
16 0 0 5	6 8	¾ in. frad. grounds.

2)	16 6	33 0	1 in. arch. mo., 2¼ w.
	7 0 4 6	31 6	1¼ in. framed closet front.
	6 0 2 9	16 6	Ddct. door.
		15 0	
	6 0 2 9	16 6	1¼ in. 2 p. square door.

No. 1 pr. 2½ in. b. and s. 1 brass knob turnbuckle.

	4 6 1 3	5 8	1 in. closet top, w. 2 sides.
	4 6	4 6	1 in. arch. mo., 2¼ w.
	4 6	4 6	1 in. dble. bdd. pin-rail.

No. 6 japd. cloak pins and screws.

	4 0 0 9	3 0	1¼ in. shelf.

No. 2 rod. corners to 1¼" shelf.

	20 0	20 0	Sqre. angle staff, plugged.

STAIRCASE FROM ONE-PAIR TO TWO-PAIR.

	22 0 3 0	66 0	1¼ in. dl. treads, 1 in. risers, glued and blocked to close string, moulded nosings, 2 fir carriages.
	6 0	6 0	Nosing to 1¼ in. floor.
	3 0 0 9	2 3	¾ in. beadd. apron lining.
	3 6 5 6	19 3	Add winders.
	13 0 0 11	11 11	1½ in. reb. and bdd. close string.
	20 0 1 0	20 0	1¼ in. wall string, plugged.
	7 0 1 0	7 0	Add ramp.

No. 30 housings to flyers. 3 housings to winders.
,, 15 square bar balusters.

	13 0	13 0	2½ in. deal mldd. handrail.

No. 15 housings in handrail for balusters.

	15 6	15 6	2½ in. dl. turned newell.

No. 2 turned pendants to newell. 2 iron screw bolts.
,, 3 housings of winders into newell.

ONE-PAIR FLOOR.

	15 0 12 2	182 6	1¼ in. yell. batt., strt. jt. floor.
2)	4 6 0 9	6 9	Add recess.
	4 2 0 5	1 9	Add ditto.
	3 0 0 5	1 3	Add.
		192 3	
	3 6 1 6	5 3	Ddct. hearth.
		187 0	
	13 0	13 0	1¼ in. mitred border to hearth.
	40 6 0 9	30 5	1 in. torus skirting.

No. 8 mitred angles to 1 in. torus skirting.

	40 6	40 6	¾ in. skirting grounds, plugged.
	7 0 0 7	4 1	1 in. sqre. skirting.
	5 0 7 0	35 0	1¼ in. bdd. closet front.
	6 0 2 9	16 6	Ddct. door.
		18 6	
	6 0 2 9	16 6	1¼ in. mo. and sqre. 4 pl. closet door.

No. 1 pr. 2½ in. b. and s. 1 cupbd. lock. 1 brass knob turnbuckle.

	4 0 1 6	6 0	1 in. w. b. s. closet top.

No. 1 rod. corner to closet top.

	5 0	5 0	1 in. arch mo., 3½ in. w.
3)	4 0 1 3	15 0	1 in. w. b. s. shelf.

No. 3 rod. corners to 1 in. shelf.

	5 6 4 0	22 0	Dl. cased frame, o. sk. and weathd. sill, 2 in. lamb's-tongue sashes, dble. hg., b. pulleys, patent lines, i. wts.

No. 1 brass sash fastng. 2 ogee cut ends to stiles of sash.

	20 0 0 5	8 4	¾ in. rebd. and bdd. linings.
	21 0 0 5	8 9	1 in. rebd. grounds.
	21 6	21 6	1 in. arch. mo., 3½ in. w.
	3 6 2 3	7 11	1 in. mo. 1 pl. window back.
	3 6	3 6	¾ in. bd. at top of w. bk.
	6 6 3 0	19 6	2 in. deal mo. b. s. 4 pl. door.

No. 1 pr. 3½ in. b. and s., 1 6 in. ⅝ in. 2 bolt mortise lock, china furniture.

	15 6 0 5	6 6	1½ in. dbl. rebd. and bbd. linings.

No. 3 dvtl. blockings.

2)	16 3 0 5	13 7	1 in. framed and reb. ground.
2)	17 0	34 0	1 in. arch mo., 3½ in. w.
	23 0	23 0	Sqre. angle staff, plugged.

STAIRCASE FROM GROUND TO ONE-PAIR FLOOR.

	21 6 3 3	09 11	1¼ in. yell. dl. treads, 1 in. risers, mitred to cut-string, glued and blocked, moulded nosings, 2 flr carriages.
	3 3 5 6	17 11	Add winders.

No. 15 returned mo. nosings. 15 cut brackets.
„ 1 curtail scroll end. 30 dvtl. housings for balusters.
„ 15 housings for steps and risers. 3 housings for winders.

15)	3 3	48 9	Grooving and tongueing treads and risers.
	15 0 0 11	13 9	1¼ in. reb. bdd. outer string, cut and mitred to riser.
	1 6	1 6	Add writhe, glued upright, reb. and bdd.
	15 0 1 0	15 0	1¼ in. wall string, plugged.
	12 0 1 0	12 0	Ditto ramped.

No. 2 tongued angles to string. 18 housings.
„ 30 1½ in. turned balusters.

	15 0	15 0	3 in. moulded and Fr. pold. mahogany handrail.
	3 0	3 0	Writhe to ditto.

No. 3 handrail screws. 1 housing to newell.
„ 1 curtail scroll to handrail. 1 c. i. newell.
„ 30 housings in handrail for balusters. 1 screw nut and joint to cap.

	6 6 3 6	22 9	1¼ in. mo. and sqre. spandril framing.

No. 1 pr. 2½ in. b. and s. 1 cupbd. lock. 1 brass knob turnbuckle.

	6 6 1 2	7 7	1¼ in. shelf.
	7 8	7 8	¾ in. chamfd. fillet, 2¼ in. wide.

No. 2 c. i. brackets and screws.

MINING AND QUARRYING.—XXII.

BY GEORGE GLADSTONE, F.C.S.

BRASS.

CONSTITUENTS — MODERN PROCESS OF MANUFACTURE — ANCIENT PROCESS — YELLOW METAL — PROPERTIES OF BRASS — LACQUERING — ACTION OF ACIDS.

BRASS is an alloy of copper and zinc, in various relative proportions, but the ordinary composition is about 70 per cent. of the former to 30 of the latter. If more zinc be added, the alloy will lose in tenacity; and all the compounds in which there is an absolute excess of zinc are so brittle as to be practically valueless. The ordinary commercial article will often be found to contain some small quantity of lead and tin, but these are generally accidental impurities, often arising from the melting down of old metal to which some solder may be adhering.

The simplest plan of making brass consists in the direct combination of the two metals when brought to a molten state; but even in this some precautions are necessary in order to produce a satisfactory result. The process may either be conducted on the hearth of a reverberatory furnace or in crucibles placed in a kiln. The principal objection to the former is the risk of great loss in the weight of the product from the readiness with which the zinc oxidises and becomes volatilised.

The crucibles used are made of refractory clay; in these a certain quantity of pure copper is placed, and heated up to just the melting-point, when small pieces of metallic zinc are gradually dropped in and allowed to mingle with the other until a suitable proportion has been arrived at. This point will, of course, be determined according to the kind of brass wanted; but in any case the quantity of zinc used will have to be somewhat in excess of that desired to remain in the alloy, as, under the most careful management, 24 lb. of copper and 12 lb. of zinc will only produce 34⅞ lb. of brass, having the per-centage composition of 68·8 of copper and 31·2 of zinc, showing that the loss is exclusively in the latter metal. Under the repeated re-meltings to which it may be subject in after use, the brass will continue to suffer some further loss in weight, and the relative proportion of copper will be found to be still on the increase.

As soon as the contents of the crucible have properly combined, the metal may at once be poured into sand moulds to make castings; but if it is intended merely to produce ingots of brass, for subsequent rolling or re-melting, closed iron moulds are used, which are gently heated prior to the alloy being poured in. The interior surface of the moulds is previously oiled, and dusted over with a little charcoal powder, to prevent the metals from adhering together.

The original process, but which is now rapidly going out of use, on account of being more tedious and expensive, though it is supposed by some to yield an article possessing superior properties, consisted in exposing the copper in crucibles to the action of a mixture of calamine or blende with charcoal. Calamine and blende are the two ores of zinc of most common occurrence in nature, and by this process of cementation the metal is separated from the carbonate and sulphide with which it is associated in the ore, and unites immediately with the copper without ever existing in a free state.

The arrangement of the furnace used in this manufacture is shown in Figs. 1 and 2, the latter being the horizontal plan at the level, A B, of one of the bed-plates of the kilns, C, D. The air is admitted through E, the open chamber below, and it thence passes up through the perforations (shown in Fig. 2) in the bed-plate, the current being increased by a flue which passes from F F into the chimney G, and which can be regulated by means of a damper as needs may require. On the bed-plate the crucibles H, H, etc., are so placed as not to interfere with the air-holes, and the space between them is loosely filled with coke, care being taken not to choke the draught. Each crucible will hold about 100 lb. of finished metal, but the weight of the ingredients which constitute the charge will be about 140 lb. The proportions of course vary according to the kind of brass to be produced, but the weight of calamine is usually in excess of that of the metallic copper, and the quantity of charcoal about one-fifth of the latter. The copper is always used in a granulated state, so as to present as large a surface as possible to the action of the other ingredients; and the calamine or blende is first calcined and finely powdered. If a brass is wanted which shall contain a large proportion of zinc, old brass is often used in part substitution of the copper. The crucibles are covered over, and the lids luted closely down, and they are kept up for some hours at a white heat; but the contents are not allowed to rise to a temperature at which the copper would melt, because in that case the liquid copper would all collect together at the bottom of the crucible, and only the upper surface would be exposed to the action of the zinc ores. After a time some white fumes of volatilised zinc will be found to escape from the stacks in the luting, which indicate that the process of conversion has so far progressed that the temperature may now be gradually reduced. The crucibles are then removed from the kiln, and opened; the dross is skimmed off the surface, and the contents then poured at once into the moulds.

Brass, under the name of yellow metal, is very largely used for the sheathing of ships, in lieu of copper; and as these sheets have to be manufactured upon a very great scale, it is not found to be practically convenient to make it by either of the processes already described. The most approved proportions for this alloy are two-fifths of zinc to three-fifths of copper, and any variation from this should rather be towards an increase of the former than of the latter metal. It does not withstand the action of the sea-water nearly so long as pure copper, but the difference in the first cost is so great as to make it the more economical for the sheathing of ships; and the gentle action to which it is constantly subject from the sea-water always maintains a bright clean surface. It is usually made in reverberatory furnaces, the copper being first reduced to a molten state; and then the zinc is gradually added. A considerable amount of oxidation necessarily takes place in this kind of furnace, and under the most careful management the loss of zinc from this cause will be so uncertain as to render it necessary to test the metal before running it out into the moulds; in practice, moreover, it is rare that the pure metals alone are used, for the old metal which is stripped from the ships' bottoms at each re-sheathing (which occurs usually about every three years) is taken back by the manufacturer and re-melted, so that further elements of uncertainty are introduced into the operation. It is usual, therefore, to draw a proof of the alloy from the furnace, just as in the refining of copper, and test the sample ingot by passing it through the rolls, and then breaking it to see the character of the fracture. This is repeated till a satisfactory specimen is obtained, when it is at once run out into iron moulds, as we have already described. The ingots are rolled out into sheets while hot, then annealed, and finally cleaned by immersion in weak sulphuric acid, and a scouring with sand and water.

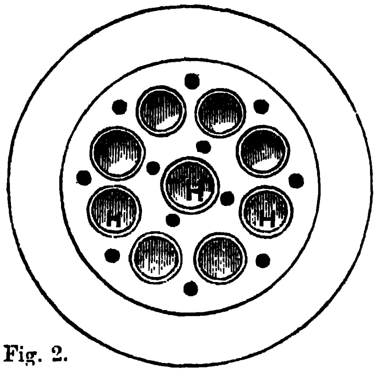


Fig. 2.

The physical properties of brass bear a strong general resemblance to those of copper; but it possesses certain advantages over the pure metal. The first of these is an economical one, the price of zinc being so very much lower than the other, that after allowing for the expense of manufacture, the cost of the product is very much lower than that of copper. The alloy is harder than either of its constituents, and is of greater density than their mean; but it melts at a lower temperature than copper, and produces very good and sharp castings, all which circumstances combine to render it a most suitable material for small engineering work. Moreover, it is less affected by atmospheric influences than copper, and by a very simple process which will be referred to presently, a most brilliant surface can be given to it which will effectually prevent it from tarnishing.

Hence it is applied to an almost infinity of uses, domestic, engineering, and scientific. It is constantly to be met with in locks, hinges, handles, buckles, and bolts; in ornaments for the table or mantelpiece; in chandeliers and gas-burners; in weights and scales; in the finer parts of nearly all steam-engines and other machines; in clocks; in mathematical and optical instruments, etc.

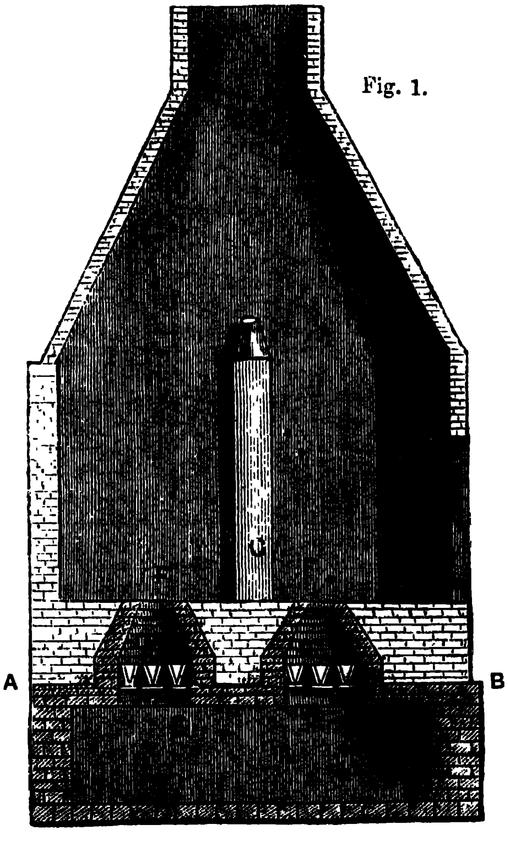


Fig. 1.

Brass is also highly tenacious, so that it can be rolled or beaten out into very thin sheets, and drawn into very fine wire. It can, indeed, be beaten out into leaf, quite as thin if not thinner than that of gold, for which it is often used as a substitute.

All these different qualities are of course more or less affected by the relative proportions of the respective ingredients; the table at the end of this article will serve to show roughly which are the most appropriate combinations for the various purposes that may be required. It should be borne in mind that the two metals will combine in any proportion; and the general character of any intermediate combination may be very fairly judged of by comparing the two given in the table between which it would take its place. As more zinc is added the alloy becomes still more brittle, it loses its fine colour, which then passes into a grey, and has no special quality to recommend it. A slight admixture of lead, not exceeding about 2½ per cent., is rather an advantage if the brass is intended to be worked upon the lathe, and a similar quantity of tin will not injuriously affect it when employed in making castings, while it is even advantageous if the brass is to be used by the engraver; but a much less proportion of either of these metals, or of antimony, will destroy its value for wire-drawing. For this last purpose the alloy cannot be too pure. A little antimony will in like manner affect the rolling of it into thin sheets by rendering the metal brittle.

Brass resembles copper in its behaviour under the hammer, and needs annealing from time to time in order to restore its malleability. During these repeated heatings the surface becomes tarnished by the formation of oxide, from which it is subsequently purified by dipping it into weak acid, and then washing it with water.

On prolonged exposure to the action of the atmosphere it gradually acquires a dirty black colour, but this can be effectually prevented by coating the surface when quite pure and bright with a thin film of lacquer. This is made by dissolving shellac in alcohol, and applying the solution to the surface by means of a fine brush. Both the articles to be lacquered, and the lacquer itself, should be thoroughly warm; and then, on drying, the thin film of lac will be found to be quite transparent, and to have so smooth and bright a surface as to resemble the most highly-polished metal. The lacquer adheres with such pertinacity to the surface that it can only be scraped off with difficulty, and the brass may afterwards be bent to and fro as much as one pleases without its being separated. By discolouring the surface of the metal, through the agency of acids or otherwise, prior to lacquering, various tints, such as those of bronze, can be produced; or a deeper tint may be given to the lacquer itself by the addition of some of the more highly-coloured resins.

If a dull or frosted surface is desired, which often forms an agreeable contrast to the other in ornamental work, it is produced by a process which is termed "dead dipping." In this case the brass is exposed for some time to a comparatively strong solution of nitric acid until the surface has become thoroughly granulated. It is then washed in pure water to remove all the acid, and next dipped in a cold weak solution of tartrate of potash, after which it is dried by rubbing it with hot sawdust. It is then ready for the application of the lacquer.

The action of acids upon various kinds of brass is not a little remarkable and instructive: for instance, a strong nitric acid will dissolve equal quantities of copper and zinc in an alloy in which the two metals exist in equal proportion, while a weak acid will especially attack the zinc and very slightly affect the copper. Indeed, if the alloy contains an excess of zinc the action of a weak acid will be much greater than if the two metals were treated separately; while if the zinc is only equal to or less than the copper, the alloy is only very slightly acted upon at all. Strong hydrochloric acid will dissolve out nearly all the zinc from an alloy consisting of equal parts of each metal, leaving the copper almost untouched. A weak hydrochloric acid will dissolve out a portion of the zinc, provided this metal is in excess; but it has no effect whatever upon an alloy of equal parts of the two metals, or of any combination in which the excess is on the side of the copper. Again, with the strongest sulphuric acid, if the zinc is in excess, zinc only is dissolved, and that sparingly; but if the two metals are in equal proportion a greatly increased action takes place, and both metals are equally attacked by the acid. A weaker acid, having the formula $H_2SO_4 + 2H_2O$, scarcely affects any of the alloys containing an excess of copper; and that consisting of equal parts of the two metals is absolutely unaffected by it.

TABLE SHOWING APPROPRIATE COMBINATIONS OF COPPER AND ZINC FOR BRASS.

COPPER.	ZINC.	COLOUR.	OTHER CHARACTERISTICS.
PER CENT.	PER CENT.		
85	15	Yellowish red.	A very hard fibrous metal, with good working qualities.
80	20	Reddish yellow.	Rolls and hammers well. Good for wire-drawing.
75	25	Brass yellow.	Good working qualities. Highly tenacious. Used in machinery.
70	30	Brass yellow.	Common brass. Works well under the hammer.
65	35	Full yellow.	Rolls and hammers well. Good for wire drawing.
60	40	Yellow.	Used for sheathing ships. Rolls moderately well.
50	50	Golden yellow.	Very fine colour; suitable for ornamental castings, but too brittle for other purposes.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXVII.—THOMAS TELFORD, ENGINEER.

BY JAMES GRANT.

THOMAS TELFORD, one of the most distinguished of our civil engineers, was born in 1757, of humble parents, in the secluded and pastoral valley of Eskdale, as the eastern portion of Dumfriesshire is designated. At the parish school of Westerkirk, he received the education which generally falls to the lot of Scottish children of his class, and was sufficiently well grounded as to make himself master of Latin, French, and German. At the age of fourteen years he left school, and was bound apprentice to a jobbing builder in his native parish, and there he worked for some years as a stonemason. At the expiry of his time he proceeded to Edinburgh, where a new town was then in the course of erection, and studied the principles of architecture, till 1782, when he proceeded to London, where his skill, intelligence, and superior education speedily found him employment under Sir William Chambers, in the building of Somerset House. His merit soon became so conspicuous that he was soon after entrusted with the superintendence of certain works for Government at Portsmouth Dockyard; and in 1787, in his thirtieth year, he was appointed Surveyor of Public Works in Shropshire, a situation which he held till his death.

In 1790 he was employed by the British Fishery Society to inspect and report upon the state of the harbours at their respective stations; and he devised the plan for that extensive establishment at Wick, in the county of Caithness, which is known by the name of Pulteney Town, a modern and thriving suburb of the ancient and royal burgh, and now in every respect, save antiquity, regarded as the town, and Wick as the suburb. Prior to the time of Telford, its site was a large barren heath on the entailed estate of Hempriggs. He designed the harbour, the streets, and a certain number of buildings adapted solely for purposes connected with the herring-fishery, which in the season finds employment for more than a thousand boats, the crews of which are Highlanders, Norsemen, and Dutchmen.

In the years 1803 and 1804 the Parliamentary Commissioners for Making Roads and Building Bridges in the Scottish Highlands appointed Telford their engineer, and under his directions more than 1,100 bridges were built, in some instances where none had existed before, and 860 miles of new road constructed in districts that prior to his day had no other tracks than the old war-paths or drove-roads of the men of Fingal's time and the clansmen of later years.

The new bridge of five arches across the Don (superseding the ancient and well-known "Brig o' Balgownie"), at Aberdeen, was built by Mr. Gibb from a design furnished by Telford. Each arch is of 75 feet span, with 24 feet of rise. Its total expense was £14,000, and though it was in an unfinished state during the tremendous floods of 1829, it escaped on that occasion without injury.

In all these and various other works executed by him in his native country, in England, and in Wales, his wonderful skill enabled him to surmount natural obstacles and difficulties of the greatest magnitude; but the most stupendous undertaking in which he was engaged, and perhaps the most imperishable monument of engineering fame, is the Menai Suspension Bridge over the Menai Strait, one of the most magnificent works in the world.

It was full time that some such means of crossing the strait were constructed, as between the years 1664 and 1842 no less than 180 persons had been drowned at the Ferry of Moel-y-don. So early as 1810 more than one design for a bridge had been designed, and rejected as impracticable; and it was not until the completion of the great Holyhead road by Telford, that he saw the absolute necessity of devising some safe means of crossing. He selected a spot called Ynys-y-moch, where the bold and rocky shores on each side gave opportunities for a lofty roadway, which was carried 100 feet above high-water mark, so as to allow vessels of the largest size to pass underneath. It is difficult for the eye to estimate the colossal proportions of this wonderful bridge in the air, and it is only after attentively observing the vehicles and human figures crossing it, and looking in the distance through the high trellis-work of iron like flies in the web of a spider, or sparrows fluttering in a net, that it is fully appreciated. A sensible vibration is produced by the passage of a vehicle, or even a man and horse; but it has withstood the greatest storms of wind almost without injury. The weight which the chains support is calculated at 489 tons, and that which they are capable of supporting, at 2,016 tons, leaving an available power of 1,520 tons to resist any unusual strain. The total cost of its construction was £120,000. The masonry is of a hard limestone from Penmaen in Anglesea.

Prior to this work, in 1808, Telford was employed by the Swedish Government to survey the ground and lay out an inland navigation through the central part of the kingdom, with the view of forming direct communication by water between the North Sea and the Baltic. Plans for this purpose had been devised, but vainly, in earlier years. In 1516, Bishop Brask proposed to connect Lake Wettern with the Baltic; Gustav I. thought seriously of it. Charles IX. was the first to commence the undertaking by opening a port called Carls-Graf to avoid the upper falls of the Göta River. In the reign of Gustavus Adolphus a commencement was made of the Hjelmar Canal, but it was not completed till 1701. At a later period surveys of a line between the Wenrern and the Baltic were taken by Daniel Thunberg, and in 1793 a company was formed for making the Trollhatten Canal by Eric Nordevall; but the real founder of the great Göta Canal was the Baron Baltazar von Platen, who in the year named, 1808, "summoned the famous Scottish engineer, Thomas Telford, and in twenty days the whole line was marked out nearly over the same ground as that contemplated by Daniel Thunberg." The work was chiefly done by the infantry of the Swedish army; and when, in 1813, Telford again visited Sweden, the gigantic undertaking was in full progress, but it was not fully open until 1822.

The genius of Telford was not, however, entirely confined to his profession. In early life he was a contributor of many pieces of considerable poetical merit to "Ruddiman's Weekly Magazine of Edinburgh Amusement," a periodical published then by the Brothers Ruddiman, in Foresters Wynd, which opened off the Lawn-market. These effusions appeared under the signature of "Eskdale Tam;" and he addressed, in rhyme, an epistle to Robert Burns, a portion of which has been inserted by Dr. Currie in his well-known life of the poet. Though he soon relinquished, as unprofitable, the task of rhyming, he remained a poet all his life.

"The poetry of his mind," it has been said, "was too mighty to dwell in words and metaphors; it displayed itself by laying the sublime and beautiful under contribution to the useful for the service of man. His Caledonian Canal, his London and Holyhead Road, are poems of the most exalted character, divided into numerous cantos, of which the Menai Bridge is the most magnificent one. What grand ideas can words raise in the mind to compare with a glance at that stupendous production of human imagination?"

The most important of Telford's public works was the planning and laying out of the Caledonian Canal, a magnificent line of inland navigation 60½ miles in length, through Glen Mhor na' Albyn, or the Great Glen of Caledonia, which extends due west and north-east from the isle of Lismore, in Loch Linnhe, to the sutors of Cromartie, on the Moray Firth. This great canal was one of a series of improvements which had peculiar reference to the Highlands and the condition of its people at that time, and was pressed upon the Government as a means for checking that emigration which threatened to leave all that part of Scotland a wilderness. It was proposed by Telford that the canal should be wide enough to admit the largest class of Baltic and American traders, or even a fully armed 32-gun frigate, with an uniform depth of 20 feet of water, and with locks measuring 170 feet long by 40 feet wide. His original estimate for this, and cutting the necks of land connecting the chain of locks, was no more than £350,000; but ere the great undertaking was concluded the sum amounted to £1,023,628, £43,500 of which was spent in obviating legal opposition and chicaneries alone.

It would appear that the present traffic on the canal is probably not 2½ per cent. of the whole trade going through the Pentland Firth. The average of tonnage passing through the canal, exclusive of steamboats and local traffic, has been about 20,000 tons per annum. To prevent the delay—sometimes of three or four months—of going round Cape Wrath during westerly winds was one of the principal objects of the canal; but this end is defeated by the circumstance that as it lies in the trough, or hollow, between two lofty ranges of mountains, the wind blows always parallel to the line of the canal, so as necessarily to be a foul wind in one direction; and, consequently, as ships can neither tack nor be tracked by horses, the whole length, which ought not to occupy more than four days, takes at times as many weeks.

Steam-vessels are now, however, placed on the canal, and the whole scenery, from Corpach to Inverness, is so singularly romantic and sublime, that its character is greatly enhanced by the passing and repassing of large vessels gliding over the bosom of these vast lakes under the shadow of lofty mountains and forests of birch and fir, thus fulfilling the prediction made by a Highland seer, four centuries ago, "that vessels with white sails would be seen traversing the lonely Glen of the Lakes."

It was opened from sea to sea, according to Telford's plans, after twenty years of labour, on the 23rd of October, 1822.

Telford was a Fellow of the Royal Societies of London and Edinburgh; and from its commencement, in 1818, was annually elected President of the Institution of Civil Engineers. His gradual rise to the summit of his profession is to be ascribed, not more to his genius, his consummate ability and persevering industry, than to his plain, honest, straightforward dealing, and the integrity and candour which marked his character throughout life. He died unmarried, at his house in Abingdon Street, Westminster, on the 2nd of September, 1834, and was buried in Westminster Abbey.

TECHNICAL DRAWING.—LXVI.

DRAWING FOR BRICKLAYERS.

When the soil on which a building is to be erected is very soft or swampy for a considerable depth below the surface, which is the worst kind of foundation that can occur, it has been usual to secure the base of the walls by a wooden grating or platform of the nature described in the last lesson, but supported upon strong piles of a length sufficient to penetrate into harder soil, and acquire a fixture there, and which are driven until they will go no deeper. Such piles are usually shod with iron, and are driven at intervals of three or four feet apart. There ought to be at least two rows of piles under the foundation of every wall, as in the example shown in Fig. 531, so that every pair of piles support a transverse sleeper.

Less than two rows of piles would not give sufficient stability to the wall even of a common building. More than two rows, or three at the utmost, can only be required for the foundation of very substantial masses of masonry, such as revetments, wharf walls, etc.

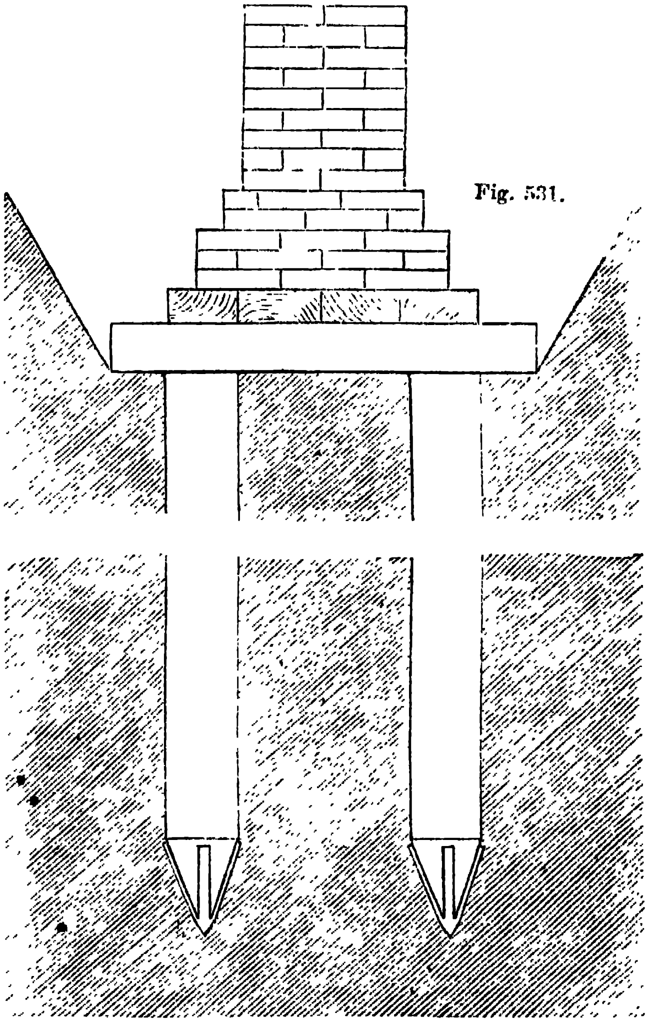


Fig. 531.

The principle of the stability derived from a piled foundation is thus described by Sir Charles Pasley:—"By the laws of mechanics the force of percussion greatly exceeds that of simple pressure by dead weight; and in the pile-engines used in this country the ram (sometimes called the 'monkey')—that is, the weight by which the pile is driven—falls upon the head of it from a considerable height, which greatly increases the effect as compared with the old system of pile-driving still used abroad, in which the ram is not raised more than four or five feet. Now the momentum of ten or twelve hundredweight, a common weight for the ram of a pile-engine, falling from the height of fifteen or twenty to thirty feet, produces a greater effect than the dead weight of any common mass of building; hence, if a pile be driven by such an engine until it can go no further, there can be little risk of the foundation giving way afterwards in consequence of the mere pressure of the walls."

Foundations built on piles are, however, liable to failure, first, from the piles losing their original position in consequence of the soft ground offering too little resistance against a lateral movement, so that the walls built on them may have a tendency to fall over. The different forms of wooden and iron piles, the pile-driving machine, and the steam pile driver are described in lessons in "Building Construction," TECHNICAL EDUCATOR, Vol. I., page 57.

In order to guard against this evil, the piles for walls are sometimes driven obliquely, so as to diverge at bottom, and those especially for leaning revetments or for the abutments of bridges may be driven in such oblique directions as to oppose the greatest resistance to the unequal pressure, which acts chiefly on one side of the wall.

Secondly, a failure may arise from wooden piles rotting or being corroded by worms in process of time, the former of which evils is almost sure to occur in foundations alternately wet and dry. Fortunately, the kind of soil where piles are most required is that where water is found a little below the surface; and if the woodwork be kept at such a level as always to remain wet, there is little or no risk of its decaying by rot. The perfect state in which trees have been found after the lapse of many centuries is well known. A few years ago, on throwing two arches of Rochester Bridge into one, the piles of the intermediate pier, which must have been there for several centuries, were taken up perfectly sound.

Reverting to the system of wooden platforms in foundations, they are of course liable to decay in process of time under most circumstances.

Now, since the uniform thickness of such platforms cannot exceed a few inches, this kind of failure taking place after the building has become completely consolidated, will not be attended with those injurious consequences which would arise from the decay of a piled foundation. Still, it is desirable to avoid using continuous planking, and to employ a couple of parallel longitudinal timbers for the same purpose, laid at a sufficient interval apart, which, when surrounded by brickwork or masonry, are called *chain timbers*.

Those are shown in Fig. 532, in which is shown a section of a portion of one of the walls of the buildings in Lancaster Place, adjoining Waterloo Bridge, London. In this illustration, which will be further described presently, two parallel chain timbers are seen in section. These, which are in thickness about equal to the height of four courses of brickwork, are laid upon transverse sleepers placed parallel to each other at certain intervals.

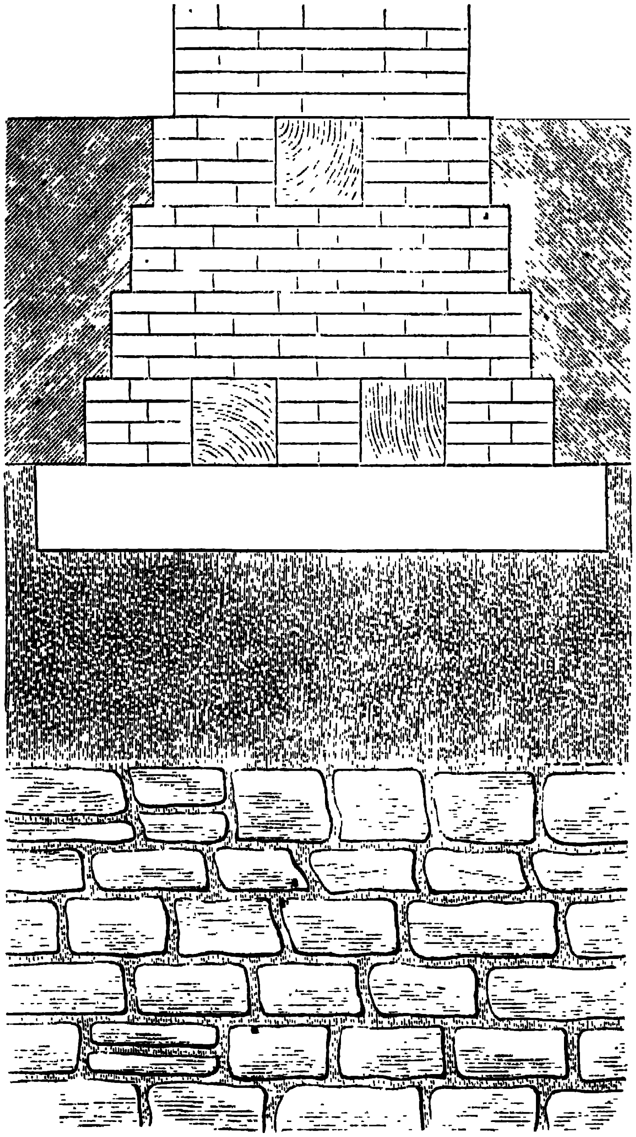


Fig. 532.

In this arrangement it will be evident that in the event of the woodwork decaying, the base of the wall will have a sufficient and solid footing on the natural ground or on the surface which has been prepared for it to rest on; for the intersecting cavities in the brickwork occasioned by the rotting of the timber are too small in themselves, and at too great intervals apart, to injure the stability of the brickwork.

It will be understood that the chain timbers which extend all round the building, and which therefore must be in several pieces, are firmly connected at the ends by scarfing or otherwise, and they are pinned down to the sleepers on which they lie. A third chain timber is also used, not on the same level with the others, in which case it might weaken the wall too much, but in the middle of the thickness of the wall, two or three feet higher up, as, for instance, at the part where the uppermost offset of the footings terminates. This third chain timber is also shown in the example, and it will be evident that the three combined will produce nearly the same favourable effect in the first instance as a continued planking, but without being liable to any of its inconveniences.

The buildings referred to are founded in very bad soil, which proved on examination to have consisted originally of soft mud, but which was intersected in all directions by the remains of the foundations of old houses and wharves. Trenches having been cut to a sufficient depth and width along the proposed line of the new foundations, fragments of the old walls were laid therein as regularly as possible, in the same manner as large flat stones might have been used. These were well sluiced with water, then mixed with grouted gravel,* and rammed down flat; the work being thus continued until the fragments alluded to were expended. Then the rough foundation was continued to the proposed footing of the brickwork with grouted gravel alone, and at that level transverse sleepers were used at intervals of about four feet apart (all under piers, none under the position of doors or windows), upon which were laid two longitudinal chain timbers of the thickness of four courses, completely surrounded by the brick, but immediately under, and flush with what was intended to be the exposed surface of the principal wall of the building after the work should be raised to a certain height; and a few feet higher, opposite to the top of the uppermost offset of the brick footing, a third chain timber of the same scantling was bedded in the middle of the wall. Thus these three chain timbers combined cover a space of not less than 2 feet 3 inches wide, being equal to the thickness of a three-brick wall, and this arrangement is continued throughout the whole extent both of the external and cross or party wall of that row of buildings.

The foundation here described is everywhere 8 feet wide, and of the same average depth. The brick footings have a base of 5½ bricks, which, by four successive offsets on each side at intervals of three courses apart, diminishes at the height of 3 feet to 3½ bricks, which is the thickness of the front and back walls of the lowest storeys of the buildings, which are vaulted and used as stables or stores. Over this the walls of the basement floor, and the inhabited part of those buildings, are 3 bricks thick, which dimension is gradually diminished by successive offsets to 1½ bricks in the uppermost storey of the house.

The height from the top of the brick footing to the coping of the parapets in front and rear is not less than 88 feet, to which, adding the footings and foundation, it appears that there is a mass of brickwork, rough masonry, and grouting nearly 100 feet in height—that is, on the side nearest the river.

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* *Grout.* A thin semi-liquid mortar, composed of quick-lime and fine sand and gravel, which is poured into the internal joints of masonry; it is particularly used where the work consists of large stones. The process is called "grouting."

SHIP-BUILDING.—XII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF IRON SHIPS.

In our remarks on this subject it will be desirable to follow the same order as was followed in describing the skins of wood and composite ships; the arrangement or disposition of the plates being first considered, and afterwards their fastenings.

The outside surface of a wood ship's bottom is flush, and in some of the early iron vessels the plating was also made flush by means of the plan illustrated (in section) by *a* in Fig. 34. It will be observed that the edges of adjacent strakes of plating are connected by narrow plates or strips, fitted inside them, and riveted to each. The strips being made continuous in a longitudinal sense, it was impossible to fit the plating directly upon the frame angle-irons, and it became necessary to fill in the spaces between the plates and the frames with pieces of iron, termed "liners;" these are shaded across in the section for the sake of distinction from the plating and strips. A flush outer surface was thus obtained, but at considerable cost. The liners, for example, taken together amounted to a considerable weight, and added nothing to the strength of the hull. Then, again, the fact that the edges of the plates were flush-jointed, necessitated more care in fitting them and caulking them, than would have been needed if lap-joints had been used; besides which the amount of riveting required in the edge-fastenings was double that needed for lap-joints. In fact, the plan was wanting in economy of material and workmanship, and it gave place to others very soon; it has, however, been again used in a few ships built recently on the Tyne.

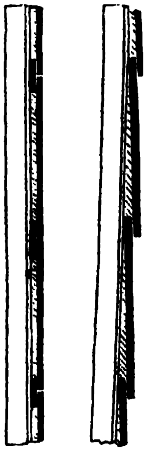

Fig. 34.

The section marked *b* in Fig. 34 shows the "clinker" plan of plating, which was formerly much used in iron ship-building, the name being derived from the resemblance of the plan to that followed in planking wood boats and small vessels. Here the upper edge of each strake is fitted directly upon the frame angle-irons, and is overlapped by the lower edge of the adjacent strake. All the edges are therefore lap-jointed, and a considerable saving in weight and cost of workmanship was consequently effected, as compared with the flush-jointed plan. Liners were still required, however, to each strake, and they will be seen to be triangular or tapering in section; thus needing to be specially shaped in order to properly fit the spaces between the plating and the frames; whereas on the other plan the liners were of parallel section, and could be cut from plates.

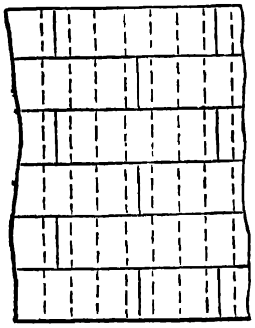

Fig. 35.

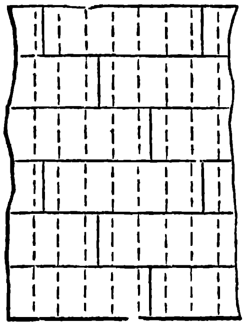

Fig. 36.

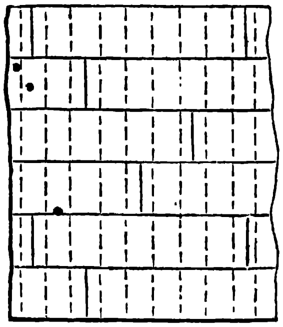

Fig. 37.

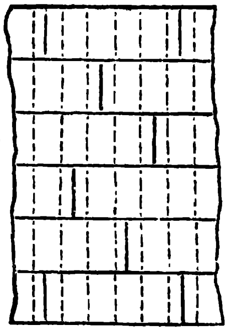

Fig. 38.

The next section, *c*, represents the arrangement now used almost universally, in plating iron ships. Alternate strakes are worked directly upon the frame angle-irons, and are termed "inner" or "sunken" strakes. The intermediate strakes overlap the inner strakes at both edges, and are known as "outer" or "raised" strakes. Liners are thus required only to one-half the strakes, and at the same time are of parallel section, so that little care is needed in fitting them; while all the advantages of lap-joints, as respects saving in riveting, weight, etc., are obtained. The fact that this plan has been so generally adopted furnishes sufficient evidence of its superiority to the two preceding plans.

The fourth section, *d*, represents a plan of plating which has not been much used, but possesses some advantages. It is usually known as "Lamb's Patent," but there is reason to believe that it had been suggested previously to the date when this patent was obtained. All the strakes of plating are worked directly upon the frame angle-irons, liners being entirely dispensed with, and their weight saved. The flush edge-joints are then secured by continuous strips, resembling those fitted in section *a*, but worked outside instead of inside the plating. Of course, this arrangement necessitates twice as many rivets being used for edge-fastenings as are required in either the clinker plan, or the in-and-out system; and it also requires the edge-strips to be twice as broad as the laps, thus adding a weight which probably exceeds that saved on the liners. On the other hand, the later plan possesses some advantage in simplicity, and the directness of connection between the plating and the frames; it entirely does away also with the necessity for using liners that do not contribute strength to the hull. Hitherto, however, ship-builders prefer the in-and-out plan, and do not seem inclined to use the other.

Many plans besides the preceding have been proposed, but have not found favour. The use of two thicknesses of plating for the skins of iron ships has been repeatedly patented, some persons preferring to work both thicknesses longitudinally, and others to work them diagonally. The latter proposal, it need hardly be said, is based upon an entire misconception of the efficiency of the skins of iron ships. The use of two thicknesses of plating is confined in most vessels to a few strakes which are situated in critical parts of the structure where exceptional strength is required; and so far as we are aware the only instance of the more extended use of the plan is found in the skin-plating behind the armour of our ironclads, illustrated in Figs. 24—26, page 224. In these vessels the double thickness is used to give greater resisting power to the target formed by the ship's side, rather than as a means of adding to the strength of the ship considered as a girder.

Other inventors have proposed to substitute special forms of plating for the plain sheets, or plates, generally employed. "Corrugated" plating has been advocated by some; "trough-shaped" plates by others; and still more singular forms that need not be mentioned. Against all those plans the great objection lies that they would necessitate considerable outlay on the mere *preparation* of the plating, besides causing more difficulty in its combination. In fact, ship-builders have unanimously declared in favour of the plain sheet-iron, which can be rolled with ease, and most efficiently combined; and this preference receives considerable support from the fact that the progress of the iron manufacture now enables much broader and larger plates to be procured than could formerly be obtained. Twenty years ago the plates commonly used were not more than 2 feet broad and 7 or 8 feet long; and now plates more than twice as broad and twice as long can be rolled without difficulty, and are often used.

Attention will next be directed to the shifts of butts usually adopted for the plating of iron ships, examples of which are given in Figs. 35–38. Before describing these, however, it is proper to remark that the butts of skin-plating are not necessarily sources of weakness, while the butts of an ordinary wood ship's planking are unavoidably so. The plating is, as we have seen, pierced at each frame angle-iron by rows of rivet-holes, and thus weakened sections are produced. If the ship-builder, therefore, can make the sections of the plating at the butts as strong as the unavoidably weakened sections at the frames, he will have done all that is needed, and the butts will not be sources of weakness. This result may be attained by means of well-arranged and well-fastened butt-straps, as we shall show hereafter; and so a closer approximation to uniformity of strength may be made than is possible in the skin of a wood ship. At a section passing through a line of butts in the latter, every fourth (or butted) strake may be regarded as practically ineffective against tensile strains; whereas in an iron skin the butted strakes can be made as efficient as need be against both tensile and compressive strains. Consequently the iron ship-builder has a greater freedom than the wood ship-builder in disposing the butts of the skin; but he must exercise great care if he would fully develop the capabilities of the iron. Not only has he to consider the relative positions of the butts of the various strakes of plating, but also their positions relatively to the longitudinal frames or strengthenings; and a neglect of the latter consideration has in some cases caused serious weakness in ships otherwise well built.

In the sketches illustrating the various shifts of butts, the *dotted* vertical lines represent the stations of the frames, and the *drawn* vertical lines represent the butts of the strakes of plating, of which the horizontal lines show the edges. The first disposition, in Fig. 35, has only *one* passing strake between consecutive butts, and is termed the "brick" arrangement, from its similarity to the method of laying bricks in building walls, etc. It was formerly much used, and was not ill adapted to the short lengths of plating then procurable; it has, however, now given place (to a large extent) to the arrangement shown in Fig. 36, termed the "diagonal" plan, where there are *two* passing strakes between consecutive butts. In this arrangement it will be remarked that the butts of adjacent strakes form "steps," similar to those which wood ship-builders are so careful to avoid in arranging the butts of the outside planking; and it may be remarked that so long as a minimum shift of from three to four feet is secured between adjacent butts, iron ship-builders do not consider it essential to avoid such steps. The third arrangement, in Fig. 37, gives *three* passing strakes between consecutive butts, and is identical in principle with the ordinary shift of butts in the planking of wood ships, illustrated by Fig. 27, page 256. It is not very commonly used, but is well suited to cases where the plates employed are from 14 to 16 feet in length. Fig. 38 shows *four* passing strakes between consecutive butts, and is much used in the construction of merchant vessels. Unlike the plan in Fig. 37, it lends itself readily to the use of plates 9 or 10 feet long, and yet gives as great a minimum shift between adjacent butts.

The ship-builder would be mainly guided in his choice of the shift of butts by the lengths of plates he proposes to use, and in fixing the latter particular would naturally have regard to the relative cost of plates of moderate or of great length. Suppose, for example, a private builder had contracted to build a ship to be classed at Lloyd's. He would meet all the requirements of the Rules by adopting the shift of butts in Fig. 38, and yet not require lengths of plates exceeding 10 feet; whereas with the shift of butts in Fig. 37 he would require plates 14 feet long. Now the shorter plates would also be procurable at the cheaper rate per ton, and it would consequently be to the builder's advantage to use them, although the number of butts in the skin would be made greater in consequence. In another paper we hope to illustrate the close connection that should exist between the shift of butts and the character of the butt-fastenings; but for the present it must suffice to mention the obvious truth, that by increasing the number of passing strakes between consecutive butts a decreased amount of fastening will give the strength required to the butts.

The term "outside plating" is applied to the whole skin from keel to gunwale. The garboard strakes, coming next the keel, are usually thicker than the remainder of the plating; and the "sheer-strakes," coming in wake of the upper-deck beams, are also thicker by $\frac{1}{16}$ or $\frac{1}{8}$ of an inch than the plating on the sides, down to the turn of the bilge. The plating from this point in to the garboards is sometimes distinguished as "bottom plating," and is generally about $\frac{1}{16}$ of an inch thinner than the garboards. Some builders, however, use plating of uniform thickness over the whole space between the garboards and the sheer-strake. The "bilge-strakes" near the turn of the bilge usually have considerable curvature in a transverse sense, and are so made specially efficient, even when unstiffened by framing, against buckling under longitudinal strains. When additional longitudinal strength is required, one very common way of obtaining it is by doubling the sheer and bilge strakes, by means of another thickness of plating worked upon them, and having the butts carefully strapped and shifted from those of the plating on which the doubling plates are fitted.

The plates used have their maximum breadth and thickness at the midship section. As the girth of transverse sections rapidly diminishes towards the extremities, the breadths of the individual strakes have to be diminished also, and some of the strakes often have to be stopped short of the stem. A similar arrangement has frequently to be adopted with strakes of planking in wood ships, and in both cases the strake abutted is termed a "stealer." Beyond the end of the stealer the two strakes which were adjacent to it on the midship section are broadened, so as to occupy the space that would otherwise be left vacant. In the case of a wood ship this can easily be done, but in an iron ship special devices are needed in order to properly secure and caulk the butt of the stealer. The thicknesses of the plates are also usually diminished towards the extremities by $\frac{1}{16}$ or $\frac{1}{8}$ of an inch; it being considered that the strength required at those parts is much less than that needed amidships. Allusion having already been made to the discussions that have taken place on this question of reduction in the scantlings at the extremities, we need only add that hitherto no definite conclusion has been reached, practical experience and the requirements of local strength having far more weight than purely theoretical considerations.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XI.

BY E. WYNDHAM TARN, M.A.

JOINERY AND IRONMONGERY (*continued*).

WE now proceed with the measurement of work done by joiner and ironmonger's fittings which was commenced in the last number.

GROUND FLOOR.

	15 0		1¼ in. tongued batten floor, with iron tongues.
	12 0	180 0	
2)	4 0		Add recess.
	0 9	6 0	
	6 6		Add bay window.
	2 0	13 0	
	3 3		Add door.
	0 9	2 5	
		201 5	
	3 6		Ddct. hearth.
	1 6	5 3	
		196 2	
	7 0	7 0	1¼ in. mitred border.
	43 0		1½ in. mouldd. and rebd. skirting in 2 heights.
	1 3	53 9	

No. 10 tongued and mitred angles to skirting.

	43 0	43 0	1 in. skirting grounds, plugged.
	6 6 5 6	35 9	Solid oak frames, rebd. and mo., 4″ × 3″, with mullion and transom, mitred and beadd. sill, 2 in. lamb's-tongue casement, circular on plan (measured nett), ¼ in. rise.

No. 2 pr. 2 in. brass b. and s. 2 brass casement fastgs.
„ 2 brass hook and eye.

	6 6 5 6	35 9	1¼ in. 2 panl. bd. flush and sqre. shutters, hg. with brass pulleys, pat. lines, lead wts.
	13 0	13 0	Groove for beads.

No. 1 brass thumbscrew and plates.
„ 2 brass sk. flush rings.

	6 6 0 4	2 2	¾ in. mahogy. flap.

No. 1 pr. 1½ in. brass b. and s. 1 brass flush ring.

	5 6 1 6	8 3	1¼ in. 2 pl. mo. window back.
	23 0 0 5	9 7	1 in. framd. and bdd. grounds.
	23 6	23 6	1¼ in. arch. mouldg, 3½ in. wide.
	25 0	25 0	1 in. picture grounds, 3½ w., plugged.
	7 0 3 3	22 9	2 in. deal 4 pl. mo., b. s door.
	17 6 1 3	21 11	1½ in. deal framed linings, 2 pl. jambs, 1 pl. soffit, moulded and dble. rebd.
2)	18 3 0 5	15 [illegible]	1 in. framed ground.
2)	19 0	38 0	1¼ in. arch. mo., 3½ in. w.

No. 1 pr. 4-in brass b. and s. 1 6-in. 3 bolt ¾ in mortise lock, and china furniture.
„ 2 pr. china finger plates.

	7 6 3 6	26 3	2¼ in. oak 6 pl. bolection mouldd. b. s. door, lower panels bead flush 1 s.
	3 6 2 0	7 0	2 in. oak ov. fanlight, circular head.
	15 0	15 0	1¼ in. arch. mo., 3½ in. w.
	6 6	6 6	Ditto circular.

No. 1 10-in. draw-back lock. 1 patent latch.
„ 2 escutcheons. 1 pr. 5-in. brass b. and s.
„ 2 10-in. brass barrel bolts. 1 brass rack chain.

	6 6 4 6	29 3	Dl. cased frame, oak dble. sunk, weathd. and throatd. sill, 2 in. ov. sashes, dble. hg. brass pulleys, patent lines, i. wts.
2)	6 6 1 2	15 2	1¼ in. mo. and bd. flush foldg. shutters, panels in 2 heights.
2)	6 6 1 0	13 0	1¼ in. bd. fl. and sqre. back flaps.
	17 6 0 7	10 3	1¼ in. proper boxings.
	13 6 0 9	10 2	1 in. plain back linings, tongued.
	4 3 2 3	9 7	1¼ in. mouldd. 1 pl. window back.
	4 3	4 3	¾ in. capping.
2)	2 3 1 0	4 6	1 in. plain elbows, rebd.

No. 2 elbow caps. 2 soffits to boxings. 1 brass sash fastening. 1 w. i. shutter bar and plates, 3 ft. long. 2 pr. 2 in b. and s. 2 pr. 1½ in. back-flap hinges and s.

	23 0 0 5	9 7	1 in. framd. grounds.
	23 6	23 6	1 in. arch. mo., 2¼ w.
	3 6 3 3	11 5	1 in. mahogy. fram. seat and riser, Fr pold.
	3 6	3 6	Mold. nosings to ditto.
	3 6 1 9	6 2	1 in. mahogy. beadd. flap and frame, Fr pold.
	7 [illegible]	7 0	½ in. mahogy. sqre. skirtg., 4 in. w., ditto.

No. 1 hole cut and dished. 1 beadd. hand-hole.
„ 2 roundd corners to skirting. 1 pr. 1½ in. brass b. and s.
„ 1 ¾-in. quarter round mahogy shelf, 9″ × 9″, on chamfd. fillets.

	7 3 2 6	18 2	2 in. dl. clamped dresser top.

No. 2 rounded corners to ditto.

	7 0 0 9	5 [illegible]	1¼ in. beadd. front to dresser.
2)	5 0 0 6	5 [illegible]	1 in. beadd. drawer fronts.
2)	7 6 0 6	7 [illegible]	¾ in. dl. dovetailed sides to drawers.
2)	3 0 2 [illegible]	14 [illegible]	Ditto tongued bottom.
	9 6	9 [illegible]	Runners.
2)	2 4 0 9	3 6	1¼ in. ends to dresser.
	12 0	12 0	Wrot. and framd. legs 2½ in. sqre.
	7 0 2 6	17 6	1 in. pot board.

	12 0 0 4	4 0	1 in. riser.
2)	5 0 0 9	7 6	1¼ in. cut and dimd. standards.
3,	7 0 0 9	15 9	1¼ in. shelf.
	21 0	21 0	Groove.
	7 0	7 0	½ in. stop.

No. 3 doz. brass hooks. 4 ebony drawer knobs.

9 6 7 0	66 6	2½ in. mahogy. lamb's-tongue shop sashes.
7 0 2 6	17 6	Ditto circular, quick.
7 0 3 6	24 6	2 in. ditto astragal and hollow folding sash doors, dimd. stiles, lower panels, mo. and bd. flush.

No. 2 pair patent swing centres. 4 brass handles.

18 0	18 0	Mahogy beadd. door frame, 3″ × 3″.
9 6 2 0	19 0	1¼ in. dl. mo. and sqre. stall board.
2 6 2 0	5 0	Ditto circular on plan, quick.
9 6	9 6	Mouldd. edge, 4 in. girt, to stall board.
2 6	2 6	Ditto circr. on plan, ditto.
14 6 3 0	43 6	Cradling to entablature, ploughed and tongued blockings.
14 6 1 6	21 9	1 in. dl. keyed frieze, joints feather tongued, lower edge rebd. for soffit.
14 6 0 4	4 10	1 in. rebd. soffit.
16 0 1 6	24 0	Dl. mould. cornice.
13 2 8 0	105 4	Revolving wood shutter with worm and wheel gearing.
8 6 3 0	25 6	1¼ in. mahogy. counter top, glued and blocked.
6 0	6 0	Mortised clamps to counter-top.
6 0	6 0	Heading joint.

No. 1 fitting and hanging flap. 1 pr. 2 in. brass b. and s.
,, 4 mitres.

3 0	3 0	Wrot. and chamfd. mahogy. fillot.
11 6 3 0	34 6	1 in. mahogy. framd. front, mod. and sqre.

SOLDIERING.—IV.

BY A STAFF OFFICER.

EQUIPMENT ARMS (*continued*)—ARTILLERY.

In speaking of the "big guns," as they are usually called, I said that we might include among them all pieces larger than those which a man can carry. The large guns are, however, again subdivided into several classes, each implying some distinctive character in the organisation with which it is connected. Thus we have, first of all, the broad distinction between the "field artillery" and the "garrison artillery." The former comprises all those guns which accompany an army in its movements in a campaign and in battle; the latter comprises those which are too large and heavy to be so used. The field artillery is again subdivided into "horse artillery," "field batteries," "position batteries," and "mountain batteries." The horse artillery is intended to act with and support cavalry, with which it has therefore to be trained. The field batteries are the special support of the infantry. They also, however, usually form the main bulk of the artillery as an arm of the service in the field. It is, therefore, an error to lay it down as an axiom or point to start from in discussing their character, that they are *intended* to work with infantry. Every arm of the service is intended to do its part in contributing as much as possible to the efficiency of the whole. We shall, therefore, consider in due time how far their equipment determines for the field batteries what that part is. At present we must be content with noting the reason for the broad distinction between the horse artillery and the field batteries.

We require to have certain guns which *can* move with and support cavalry. As those guns must be able often to be moved at a gallop for great distances, and at all times at the same rate as cavalry ordinarily moves, it is clear that they must not be very heavy. Moreover, with these weapons there is another difficulty in very much increasing the size of the piece; for as the gun is made larger, the ammunition you have to carry with it becomes rapidly much heavier in proportion to the number of rounds. As, therefore, we cannot afford very much to diminish the number, we must on this account also restrict the size of the gun which is specially intended to accompany the cavalry.

But we want also to have with us, in a condition to be used as effectively as possible, the heaviest guns we can get. Moreover, we want to be able to place these just where they will be most effective, and, time being always of value, to place them there as rapidly as possible. Now it is quite possible for a gun to be moved very rapidly about which would yet be altogether too heavy itself, and would require too heavy ammunition, to fulfil the condition of moving with cavalry. This has led to the formation of the "field batteries."

Once more, it is quite possible that though a gun may be too heavy to be moved rapidly about the field and put just in the positions in which it is wanted at every moment, yet that if we once knew where the really decisive point was, a few such very heavy pieces might be moved up thither. Now as very heavy guns produce an immensely greater effect, both physical and moral, than the lighter kinds, it is well worth while to have, for the special purpose of being brought up to the most desirable point at the most decisive moment, a certain number of such guns. This consideration has led to the formation of "batteries of position."

The purpose for which "mountain batteries" have been formed is sufficiently indicated by the name. Obviously a gun must be of very light construction which is intended to be able to accompany the army by any mountain foot-path.

In general, the means by which the several degrees in the need of free movement of the different classes of guns (with the exception of the mountain gun) is met, is by an employment of horses adapted to the work required. So essential to both the horse artillery and the field batteries is rapidity of movement that the horse is almost as much an element in their actual fighting equipment as he is with the cavalry. The extreme importance of good horsemanship for the artillery requires some explanation. A gun cannot be fired whilst it is being transferred from place to place. The gun always travels with its back part or "breech" towards the horses' heads. It has to be "unlimbered," as it is called—that is, unhooked and turned round—before it can be loaded, pointed, and fired. Moreover, as the distance is very considerable at which artillery always opens fire, that distance can only be guessed very roughly. A trial shot at least, if not more, has to be expended before a sufficiently accurate estimate can be made of the range or distance of the object aimed at. Hence every movement made by artillery from place to place represents a serious loss of power, due less to the distance moved over than to the number of moves. Moreover, if a thoroughly good commanding position has been taken up at first, the artillery gains little by being only *rather* nearer to the enemy. To the infantry every advance is a clear gain, both in the effect with which their fire can be brought to bear, and in their approaching nearer for the final rush. The artillery, on the other hand, if they can fairly see what they are firing at, can modify the distance at which their shot strikes, within such a very wide margin, that it is not worth while for them to move, except over a considerable distance. Nevertheless, very distant artillery fire is never very effective. It is in the comparatively close firing, where the effect of every shot can be seen, that the power of artillery comes out in all its deadliness. Artillery cannot be too close, provided it is just out of effective infantry range, and in a good position.

At the beginning of an action, moreover, the artillery is usually pushed forward into the most advanced positions which have been already secured by small bodies of the infantry. This is done in order that the two points in which it is superior in its fire to the infantry—its long range and weight of projectile—may be made to tell with their full effect on the enemy's position before the infantry moves forward to the attack. But as the artillery fire from these first positions begins to take effect, the enemy's fire slackens and the infantry is able to advance. The infantry thus secures positions from which the artillery can act with far greater effect. It is then that the artillery has to be moved at great risk rapidly and boldly forward. Hence, for the field batteries, which are the portion of the artillery mainly concerned in bringing crushing fire to bear on the enemy's position, the two great necessities are, as they are also for the horse artillery, rapidity and facility of movement:—the one, in order that as short a time as possible may be wasted in the ineffective period of advance, and that the guns may be allowed to remain a long time at the same spot, yet be brought up at the moment when they are wanted to a new one; the other, in order that the positions selected for the guns may be chosen so as to obtain the most effective fire, and that wherever such considerations would suggest that guns ought to go there they may be able to go. Now, these two necessities of rapidity and facility of movement can only be provided for by having the horses in the highest possible condition, and both horses and men trained in the highest possible degree.

Thus the horse, though he does not with the artillery aid as he does in the cavalry in the actual blow by which the power of the weapon is made to tell, is yet so intimately concerned in paving the way for each successful effort of the guns, that he is as essential an element in the fighting power of a battery as he is in that of a squadron.

There are six horses to each gun, and of these the three on the left-hand or near side are ridden postilion fashion by three men, each of whom also drives the horse beside him. Two gunners sit immediately behind the horses on the front of the gun-carriage. This front consists of two boxes, each carrying ammunition, *i.e.*, shell and cartridges; solid shot being never carried by artillery in the field. (For the different classes of shell carried see the papers on "Weapons of War.") Each front of a gun-carriage is thus a small field magazine for the supply of its own gun with ammunition. The whole gun-carriage when put together forms a four-wheeled vehicle. When the gun is unhooked, the front part, or "limber," forms a two-wheeled cart carrying the ammunition-boxes. The gun when unhooked rests partly on the axle-tree arms of the other two wheels, and partly on the point or end of a solid block of wood called the "trail," which supports the bed on which the gun rests. When the gun is thus in action the end of this trail rests on the ground. In order to hook the gun on to its carriage, the end of the trail, which consists of a solid iron eye, fastens into a solid iron hook at the back of the "limber." After the gun has been unhooked it can be moved by hand for considerable distances, if a sufficient number of men are available to work it, and the ground is not very heavy. The trail is lifted by three men, while as many others as are available work the gun forward by pushing at the spokes of the wheels. This explanation applies both to the horse artillery gun and to that of the field batteries. Each, too, has a wagon attendant upon the gun. This wagon consists of a limber exactly similar to that of the gun-carriage, and a "wagon body." The latter is a sort of double limber, having four ammunition-boxes instead of two. The whole wagon forms a four-wheeled carriage. The wagon body hooks on to its limber just in the same way as the gun hooks on to its limber. The limber of the wagon can, as soon as the ammunition in that of the gun is exhausted, move up and take its place whilst the limber of the gun is being re-filled from the body of the wagon.

It is essential that the wagon should be placed as completely out of danger of being struck by one of the enemy's shells as it can possibly be; for there is no object whatever in the wagon being exposed to the same extent to which the gun must often be to the enemy's artillery. The gun has its position selected quite as much with a view to enable it to fire with effect as to be itself safe. The wagon cannot fire at all. It has no means of acting whatever by itself, being simply a magazine of ammunition. Its size is very much greater, and therefore affords a very much more conspicuous mark than the gun when the latter is in action. For the wagon remains with its limber attached to it and all the horses hooked into the limber, while the horses and limber of the gun are taken out and sent to the nearest convenient protection. Above all, if the gun is struck by a shell, it does not at all follow that any irreparable injury is done to it; if the wagon is struck by even a large splinter, that splinter may cause all the large store of ammunition contained in the wagon to explode. Now that store is so great that it is quite sufficient to explode, one after another, all the other wagons, and by the general explosion destroy the limbers and guns also, unless the wagons have been removed to a safe distance. At the battle of Speicheren, during the war of 1870, an entire battery was thus swept completely away. Not another round was fired from it. Almost every man in it was killed. The entire destruction was due to one shell, part of which struck one ammunition wagon and exploded it. He would be a very bold man who would undertake that any battery in which a wagon not far removed to the rear had exploded should ever fire another round. The question, therefore, under the present conditions of all efficient fire, is one vital to the existence of artillery. For the horse artillery it is one easily solved; for the field batteries the solution has not yet been found, or at least applied; and it is at this point that the great distinction between the arrangement of the two appears.

The horse artillery, the purpose of which is essentially different from that of the field batteries, requires an altogether different fighting equipment from that of the latter. As it is to act expressly with cavalry, a number of mounted men belonging to the battery itself ride with it. When the gun is to be unlimbered and brought into action, certain of these men, in addition to the two sitting on the limber of the gun, dismount in order to load, lay, and fire the piece. Others are employed to hold the horses of those who dismount, while some of the horses are held by the drivers of the centre horses. Cavalry actions are always quick, sudden, and short. Therefore, the artillery which accompanies cavalry requires to have with it very few rounds of ammunition. Accordingly, horse artillery never moves for action with its wagons. The wagons keep away at a safe distance, and when it is necessary to replenish the supplies with the guns, they send up their limber after the action is over. Thus there is hardly any danger of a wagon's exploding. If, by chance one does explode, few men are injured, and the efficiency of the battery is not impaired. The field batteries, on the other hand, have, with the exception of the officers and a few non-commissioned officers, no mounted men riding with the battery. The men who are to lay, load, and fire, sit either on the limber of the gun or on the limber or body of the wagon. For ordinary times—for marches, that is to say, and even for the latest movements up to the moment of coming within range of the enemy—the plan is entirely satisfactory. Field batteries do not require to move very rapidly at such times, and the wagons can trot at a very good pace—can, in fact, move almost as rapidly as the guns. But when the gun is to move up to a position for action the whole difficulty of the case presents itself. It is far too dangerous to allow the wagon to move forward where the gun is. Yet unless the wagon does accompany the gun, how are the men to get there who are to work the piece? The gun is wanted up in a great hurry. Till it can be moved to a certain position nothing can be done. The gun dashes up at a gallop. The wagon stops at the last point to which it can safely move. Often it is necessarily delayed even at a more distant point; for during that last critical movement when the enemy's position is being approached, no portion of the army can be allowed to encumber the way which is not capable of bringing direct action to bear against the enemy. The wagon, therefore, a mere magazine and transporting carriage for men, has to allow masses of infantry to pass it. The gunners dismount and rush up after the gun. But men cannot race with horses, and the gun has all along had a considerable start over the wagon. The gunners, therefore, from the wagon arrive panting and unfit for work many minutes after the gun has reached its destined position. Those minutes are all precious. It is not possible to fire from the exact spot where the horses are obliged to drop the gun. The very reason for the selection of the position is, that there is a convenient bank a few yards off where cover will be just sufficient for the guns and the view perfect. Yet it is hopeless, with the only three men available, to push the gun by hand over the heavy ground intervening. All waits for the artillery. The infantry cannot advance a step till some relief has been obtained from the deadly fire of the enemy's position. It is a time when every officer in the brigade, from the youngest subaltern of infantry to the brigadier-general himself, has more than enough to do with his own work. All eyes and thoughts are strained in watching the enemy's position. Yet no one but the brigadier and his staff are near enough to the guns at the critical moment. Already the enemy have seen the tall headgear of the drivers showing over the bank. In another moment they will have found the range, and may render it impossible for the guns to open fire at all. Down jump brigadier and staff, abandoning all thoughts and cares, lending hard mechanical aid in pushing forward the guns into position. This is no fancy picture. An account of how it occurred in the Crimea may be read in Mr. Kinglake's description of the bringing up of the 18-pounders at the Alma. The remedy was then pointed out. Yet during the autumn manœuvres of last year (1871), in the attack on the Hog's Back, exactly the same thing occurred again as happened seventeen years before. Brigadier-General Browne and his staff assisted personally in pushing forward the wheels of the guns that were brought into position at the village of Seale. Newspaper correspondents applauded the zeal displayed by the officers. Others may, perhaps, mingle with their applause some regret that such waste of power should be necessary. The price in the labour market of a man who can push a wheel is not quite so great as that of one who possesses the capacity to govern 5,000 men. The moment chosen for placing the brigade commander under the necessity of taking part in the mechanical employment, is precisely the one when his higher powers are of exceptional value.

Experiments are now being made with the intention of ascertaining how the difficulty can best be met. It is to be hoped that a satisfactory solution may be arrived at; for it is useless to disguise the fact that since brigadiers can scarcely be provided to work every gun, till some other means of having men to work them, when they are wanted, have been found, our splendid field artillery can scarcely enter upon a campaign at all without the most serious risk.

Various means have been employed by different armies for avoiding the difficulty. Our own Indian artillery used to have gunners on the three horses at present driven, not ridden, by the drivers. The Prussians have men seated on two boxes on the axle-trees of the gun itself. These, with the three men who can be put on the limber and the non-commissioned officer who rides in charge of the gun, manage the handling of the piece fairly well. Our present experiment consists in providing the men with seats on the axle-tree boxes. Unfortunately, we have forgotten to provide them with any satisfactory support for their feet, and the bars to their seats are so uncomfortable that it is by no means easy to ride in them. The gun-carriages have no springs, and cannot have any; for travelling as they necessarily do over very rough ground, only a strong simple construction can be employed. Hence, as the moving a gun often requires very considerable exertion, and the men ought to be quite fresh and up to hard work when they dismount, it is very necessary that their travelling should be made as little fatiguing to them as possible. When the difficulty has been satisfactorily met, either by some means of this kind, or, which is no doubt the easier and simpler plan, by adding one or two more mounted men to the complement of the battery, the field artillery will be able to assume its own definite position and proper place. At present it is, from the circumstances I have explained, in so precarious a condition that it is indispensable to note the changes that must sooner or later be made in it.

The "position batteries" are drawn over the ground by large teams of strong horses intended simply for slow draught, not for manœuvring purposes. Hitherto we have not had any of them formed and kept ready for work in the way in which our horse artillery and field batteries are. But the guns are made, and occasionally they are horsed for the purpose of some large review or for practice. Obviously the same high training is not necessary for those who are to drive and direct them, in order to enable them to move satisfactorily, as they are required. But for them in proportion high training in the use of their weapon for shooting purposes is indispensable, as it is indeed also for both the horse artillery and field batteries. Of this subject I shall, however, have to speak somewhat more fully by-and-bye. At present it is the distinction in the characteristics of the several artillery weapons, as determining the nature of their organisation and use, on which I wish to fix attention.

The mountain guns are usually carried on the backs of mules; the gun on one mule, the gun-carriage on another. These are dismounted and put together when required for use.

In addition to the other classes of weapons which I have enumerated as belonging to field artillery we now include the mitrailleuse; for it has recently been recommended, by the committee appointed to investigate the question, that this instrument shall be employed like other classes of guns in regular batteries. It has one important distinction from all other classes of artillery, however, and it is therefore here that it is convenient to notice what is, for all other kinds of guns, their specific characteristic. They all depend for their effect upon the great superiority both of the distance to which they can throw their projectiles and of the weight of these projectiles themselves over the distance and weight of infantry fire. But the gunners cannot both attend to the handling of their big gun, and at the same time use any small weapons which will enable them to protect themselves if any body of armed men gets close up to the gun and among them. The big gun cannot be well handled against the multitude of small ones over which it has under these circumstances no advantage from its superior range of fire. The gunners, if alone, are therefore helpless victims to the fire of the assailing infantry. Hence artillery can never be left to protect itself. It always requires an escort to guard it. The whole efficiency of its action turns on its being employed just out of the effective range of infantry fire, or at greater distances than that. Thus, though artillery is alike valuable to the army which is on the offensive, and to the army which is on the defensive, its value to the army on the defensive depends on its power of striking such heavy blows against the assailant that he is not able to commence his operations effectively, rather than on its capacity for actually defending the position against him on which it is itself placed. Now the function of the mitrailleuse is the exact opposite of this. It scatters its storm of bullets most effectively from just beyond the range of ordinary infantry fire up to the ground in front of its own muzzle. Hence its action is essentially defensive—defensive of the very spot on which it is placed. It would be too much to say that mitrailleuse batteries will not require, like artillery, escorts to protect them; for they will require all the attention of the men who work them, who will, therefore, be personally unarmed; and at best these men will not escape when defeated so easily as the infantry can do, without abandoning the weapon.

We need not concern ourselves further for the present with the characteristics of the weapons of the field artillery. The yet heavier pieces which are employed by the men who form what is known as our garrison artillery are of one or two kinds. Either they are too heavy to be moved about at all, when they are kept either in fortresses or in batteries specially designed for coast defence; or they are such as would be required by an army for the purposes of a siege. In either case the first special characteristic of the weapons which affects the character of the organisation and training of the men who work them is the great size and weight both of the guns themselves and of the projectiles which they throw. From both of these, but more especially from the immense size and weight of the guns, it results that mechanical skill of the highest kind is required to move them without an undue expenditure of labour. Every kind of material appliance has to be used, and the men have to become not only, as it has been well said, "skilled mechanics," but mechanics skilled to *work together* in a way that few mechanics are accustomed to work. But this is not all. From the size of the projectiles it is possible (as those will have seen who have studied the papers of THE TECHNICAL EDUCATOR specially devoted to the arms now used) to render them immensely more effective by elaborate workmanship. The explosive materials used are of the most terribly destructive kind, and their care requires a special training of its own. Hence on all these accounts the care and management of the weapon in all its parts, gun and projectile, requires and properly occupies all the attention of such men as are to be really skilled gunners; more especially since, where such enormous masses are to be thrown by a single piece of ordnance, it is of the utmost importance that they should be accurately thrown into the very place where they are intended to create destruction; and therefore the training of the gunners to shoot well requires much time and care. There is one point which is a common characteristic of all classes of artillery weapons. When a very great effect is to be produced upon any one part of an enemy's position, the purpose is to throw into that part as many projectiles as possible. Hence, as guns throw their shot and shell from a very great distance, it is not at all necessary that the guns whose projectiles are all to hit the same place should be themselves all near together. Hence, since nearly always it is more important to produce a great effect at one point than a little effect at a great many, our great object is to concentrate the fire, but to scatter the guns; for since the scattered guns can concentrate their fire, they will be as effective against the enemy, and will be a smaller mark and less observable by him.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXVIII.—LEONARD EULER, F.R.S.

BY JAMES GRANT.

THIS distinguished mathematician, who became Director of the Royal Academy of Berlin, Member of the Imperial Academy of St. Petersburg, Fellow of the Royal Society of London, and Corresponding Member of the Royal Academy of Sciences at Paris, was the son of humble but respectable parents, Paul Euler and Margaret Brucker, and was born on the 15th of April, 1707, at Basle, in Switzerland. "The years of his infancy," says M. Fuss, "were passed in a rural retreat, where the example of virtuous parents contributed greatly to form him in that amiability of character, and uncommon purity of sentiments and manners, which were manifested during the whole course of his life."

Though the wishes of his father, then pastor of the village of Riechen, were that Leonard Euler should study for the Church, he preferred science, and applied himself with success to mathematics under the celebrated James Bernouilli, who in 1687 had been appointed a professor in the university of Basle, which had long ranked as one of the most famous seminaries in Europe. Euler attended its classes with strict regularity, and as his memory was wonderful, he performed his tasks with rapidity, and all the time he gained was devoted to geometry, which became his principal study. Euler hence became the favourite pupil of Bernouilli (then esteemed one of the first mathematicians in the world), whom his genius and rapid progress inspired with genuine admiration.

In 1723, Euler took his degree as Master of Arts, and on that occasion delivered a Latin discourse in which he drew a skilful comparison between the philosophy of Newton and the Cartesian system. He afterwards applied himself to the study of theology and the Oriental languages, and he became the friend and intimate associate of the two sons of Bernouilli, Nicholas and Daniel, through whom it was that his connection with the Academy of St. Petersburg came to pass. Peter the Great's project of erecting that academy was afterwards executed by Catherine I., and on the two young Bernouillis being invited to the Russian capital in 1725, Euler promised to follow if they could procure for him a suitable appointment; and in the meantime he applied himself to the study of physiology, and attended closely the medical lectures of the most eminent professors at Basle.

While thus engaged, he composed a "Dissertation on the Nature and Propagation of Sound," and an answer to a prize question concerning the *masting of ships*, to which the Academy of Sciences adjudged the *proxime accessit*, or second rank, in 1727. From this discourse and other circumstances, it would appear that the comprehensive mind of Euler had curiously enough been turned to the study of navigation—a study which he afterwards enriched by many valuable discoveries.

The lot of certain civil and academical honours which he deemed his due having been decided against him, he left Basle, not without a certain sense of mortification, joined Daniel Bernouilli at St. Petersburg, and with him became joint professor in the university. He now produced several memoirs and papers, and carried to new degrees of perfection the integral calculus, invented the calculation of functions, reduced analytical operations to a greater simplicity, and thus threw a new light on many parts of mathematical science.

In 1730 he was appointed Professor of Natural Philosophy, and three years after succeeded, in the chair of mathematics, his friend Daniel Bernouilli. In 1735 the Academy proposed a problem which required expedition, and for the solution of which the most eminent mathematicians demanded the space of some months. To the astonishment of the Academy it was solved by Leonard Euler *in three days*, but so laborious had been the task, that it cast him into a dangerous fever and deprived him of his right eye. The Academy of Sciences at Paris, which in 1738 had adjudged the prize to his memoir on "The Nature and Property of Fire," proposed for the year 1740 the subject of "Sea Tides," a problem requiring the most arduous calculations, together with a comprehension of the entire solar system. The discourse of Euler on this subject was deemed an exhaustive masterpiece, and it was thought more honourable for him to share the academical prize with such illustrious rivals as Daniel Bernouilli and Colin Maclaurin of Edinburgh, than to have carried it away from others of less reputation. "Rarely, if ever, did such a brilliant competition adorn the annals of the Academy; and no subject proposed by that learned body was ever treated with such accuracy of investigation or force of genius, as that which here displayed the philosophical powers of those three extraordinary men."

On being invited in 1741 to Berlin, where the Academy was then rising into form under the auspices of Frederick the Great, he enriched the last volume of "The Miscellanies of Berlin" with five memoirs which make the principal figure in that collection. With astonishing rapidity other papers followed on the most important subjects, and these are scattered through the "Memoirs of the Prussian Academy," which, ever since its final establishment in 1744, has published one volume annually. The labours of Euler were the more surprising, when it is borne in mind that he did not discontinue his philosophical contributions to the Academy of St. Petersburg, which granted him a pension in 1742, when he was in his thirty-fifth year; and it was with much difficulty that in 1766 he obtained permission from Frederick to leave Prussia and return to the Russian capital, where he was anxious to pass the rest of his life.

Soon after his return, which was nobly rewarded by the munificence of Catherine II., he was seized with a violent disorder, which terminated in the total loss of his sight! A cataract had formed in his left eye, which had become seriously impaired by too close application to study, and thus he was deprived of the use of that organ; and it was while in this distressing situation, that the untiring philosopher dictated to his servant (who had been a tailor's apprentice, and was totally ignorant of mathematics) his "Elements of Algebra," a work which, though purely elementary, discovers all the characteristics of an inventive genius. It excited applause and astonishment by the circumstances under which it was composed; and in it alone is to be found a complete theory of the analysis of Diophantes, a mathematician of Alexandria, who flourished before the Christian era, and an edition of whose works, with notes by M. Fermat, was published at Paris in 1670.

When his "Elements" appeared, the Academy of Sciences at Paris honoured him by naming him one of the foreign members of that learned body, and adjudged the prize to three of his memoirs concerning "The Inequalities in the Motions of the Planets." The two prize questions proposed by the same academy for 1770 and 1772 were designed to obtain from astronomers a more perfect theory of the moon.

Assisted by his eldest son, Euler, though totally blind, and in his sixty-fifth year, was a competitor for those prizes, and gained them both! It was a wonderful effort of genius to be able to arrange all his vast calculations by the power of *memory* alone, and when, by embarrassment in his domestic circumstances, a fire having consumed his library and much of his property, compelling him to quit a house which by long habit was familiar to him, he had to compose "a work which alone was sufficient to render his name immortal."

In the great fire of 1771, in addition to the loss of his library, he nearly lost his life. M. Grimon, a native of Basle, on learning that the flames had reached the house of Euler, boldly pressed through the conflagration, and rushing into the apartment of the blind philosopher, brought him out on his shoulders at the greatest risk. By the courage and ability of Count Orloff, the whole of his MSS. were saved.

In this last memoir he reserved for further consideration several inequalities of the moon's motion, which he had failed to determine in his first theory, on account of the complicated calculations in which the method he then employed had engaged him. With the assistance of his son, he had the courage to review his whole theory, and to pursue his researches until he had constructed the new tables, which, together with his great work on the moon, appeared in 1772. Working in darkness, "the heroic patience and tranquillity of mind he displayed need no description," to quote an eulogy of Euler; "and he derived them not only from the love of science, but from the power of religion. His philosophy was too genuine and too sublime to stop its analysis at mechanical causes; it led him to that divine philosophy of religion which ennobles human nature, and can alone form a habit of true magnanimity and patience in suffering."

About this time the famous Wentzel, by couching the cataract, restored the sight of Euler; but the satisfaction and joy of that restoration were of short continuance. By some negligence on the part of the surgeons, and his own impatience, perhaps, to use an organ the cure of which was not complete, he lost his power of vision a second time, and the relapse was accompanied by tormenting pain. However, with the assistance of his son, and Messrs. Kraft and Lexell, he continued those labours of science with an ardour which neither blindness nor the infirmity of advanced age could damp. His lunar tables were, at the suggestion of Turgot, rewarded by the Board of Longitude in France; and when the more perfect tables of Mayer obtained the great premium of £3,000 offered by the British Parliament, the sum of £300 was awarded to Euler for having furnished the theorems made use of by Mayer in his work.

In 1773, Euler published at St. Petersburg his great work on the construction and management of vessels. A new edition soon after appeared at Paris, and by desire of Louis XVI. it was introduced into the schools of marine, and a reward of 1,000 roubles transmitted to the author, accompanied by a handsomely worded letter written by the celebrated Turgot. Almost at the same time Italian, English, and Russian translations of it appeared, and the Government of Catherine II. presented Euler with a gift of 2,000 roubles. Though blind, in the course of seven years he transmitted no less than *seventy* memoirs to the Academy of St. Petersburg; and about two hundred more, that he had written or dictated, were revised for him by his friend Nicholas Fuss. "Euler's knowledge," says the latter, "was more universal than could well be expected in one who had pursued with such unremitting ardour mathematics and astronomy as his favourite studies. He made a very great progress in medical, botanical, and chemical science. What was still more extraordinary, he was an excellent scholar, possessing what is generally called erudition in a very high degree. He had read with attention and taste the most eminent writers of ancient Rome. The civil and literary history of all ages and nations were familiar to him; and foreigners, who were only acquainted with his works, were astonished to find in the conversation of a man, whose long life seemed solely occupied in mathematical and physical discoveries, such an extensive acquaintance with the most interesting branches of literature. No doubt, in this respect, he was much indebted to his most uncommon memory, which seemed to retain every idea that was conveyed to it from reading or meditation. Hence he could repeat the 'Æneid' of Virgil from beginning to end, and indicate the first and last lines of every page of the edition he used."

Several attacks of vertigo, in the spring of 1783, did not prevent him from calculating the motions of air-balloons, which at that time occupied the attention of philosophers. On the 7th of September he dined with M. Lexell, and spoke of the planet Herschel. Soon after he was amusing himself with one of his grandchildren, when on a sudden his pipe fell from his hand, and he expired of an apoplectic stroke, in his seventy-sixth year.

Euler was twice married, and had three sons and two daughters; the latter predeceased him, but twenty-six out of thirty of his grandchildren were alive at the time of his death, which was deemed a national calamity by the Russians, and the Academy of St. Petersburg decreed him a marble bust at their own expense. A complete list of his works occupies no less than fifty-one pages of Nicholas Fuss's "Elogé," which was published there, in quarto, in 1783; and a collection of the best productions of Euler appeared at Brienne, in eighteen volumes, in 1797.

Euler was a rigid Calvinist, and so long as his sight was spared he assembled the whole of his household every evening and read a chapter of the Bible aloud; he was wont to add a little exhortation or discourse, theology having been from his boyhood one of his favourite studies. His habits were ever sober and temperate; his manners unaffected and pleasing; his temper cheerful and happy.

THE LATHE.—VIII.

By Henry Northcott.

SLIDE-RESTS (*continued*)—MODERN HAND-LATHE.

The slide-rest illustrated at Fig. 25 is of more modern design than those hitherto noticed. This instrument is intended chiefly for operating upon metals, whilst the previous ones were adapted chiefly to act upon more tractable materials, and as a consequence of this difference in the nature of its work the present slide-rest is constructed wholly of iron, and of more massive proportions. In action it is precisely the same as those already described—that is to say, it has a foot-plate, *a*, which is planed underneath, so that it may bed nicely down upon the planed surface of the lathe-bed, and carry the various slides duly level and square. The slot shown along the foot-plate is, of course, for the holding-down bolt to pass through it.

It may be remarked here that the bottom surface of the foot-plate of any slide-rest should not only be planed and rendered smooth, but its area should be large, so that it may steadily support the slides against the pressure resulting from heavy and irregular cuts. If the foot-plate be too narrow, the whole rest becomes very unstable when a heavy cut is being removed from a piece of work, and this unsteadiness becomes especially noticeable when the tool is moved to the end of its slide on either side, as then the tendency of the strain upon the tool is to upset the rest or to depress the cutting tool. Many slide-rests are rendered almost unserviceable from having a foot-plate too narrow to firmly resist the pressure upon the tool.

The slide-rest also has a strong traverse-slide, *b*, with the usual screw and winch-handle, and also a surface-slide, *c*, the top part of which, *d*, is the tool-plate. The tool-holder is somewhat different from those heretofore described, consisting of a flat plate with three screws in it. The plan of this plate is triangular, and the three screws are placed one at each of the three corners of the triangle. The plate has a hole through its centre by which it is supported upon the central spindle, and the fit is a loose one, so that the plate may be swung round upon the central spindle, and placed in any position with regard to it. The tool is placed under two of the screws, and is fixed at any angle that the nature of the work may render

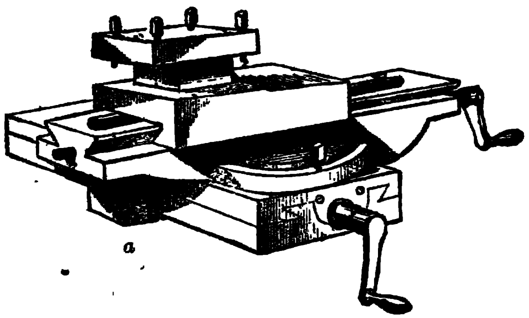

Fig. 26.—COMPOUND SLIDE-REST.

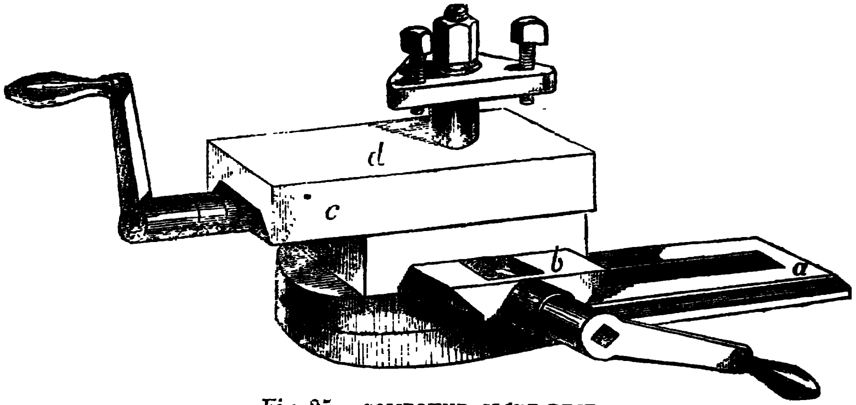

Fig. 25.—COMPOUND SLIDE-REST.

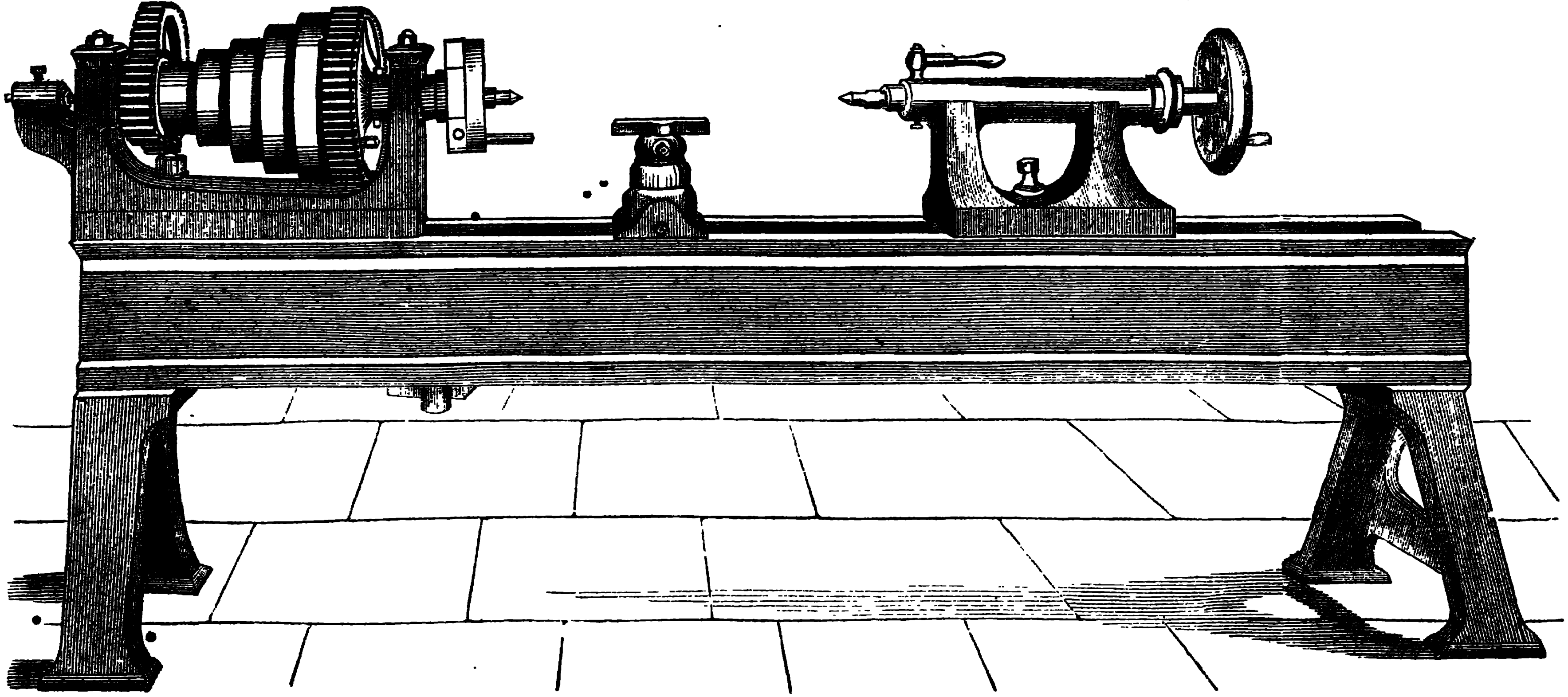

Fig. 27.—HAND-LATHE, CONSISTING OF TWO HEAD-STOCKS, CATCH-PLATE, FACE-PLATE, REST-SOCKET, AND TOP CONE-PULLEY.

necessary by tightening the two screws down upon it. The third screw acts simply as a support to the other corner of the triangular plate, to keep the plate horizontal, and prevent the two screws holding the tool down from throwing any cross strain upon the central bolt. A convenient and efficient tool-holder is quite essential to the satisfactory action of any slide-rest. This one is simple, and its principle is good, but in the example it is not so well carried out as it might be, and more favourable specimens will be met with hereafter. The three screws should in every case be made of steel and hardened throughout, but their points should be left somewhat harder than the thread of the screw, as they come in contact with the hard steel tool, which would otherwise flatten or "upset" the ends of the screws. It is advisable also that the plate should be of a good thickness, especially at the part where the screws go through it, as the continually screwing down so hard and unscrewing these screws soon wears out the thread if the plate be thin.

At Fig. 26 is shown another and more complete example of a compound slide-rest. This one also is constructed wholly of metal, and all the sliding surfaces are planed up, and should be scraped to a true surface. The projecting rib at *a* goes between the two slabs of the lathe-bed to preserve the parallelism of the traverse-slide, and the position of the rest generally. The arrangement of the traverse and surfacing slides is shown very clearly by the sketch. They are constructed in much the same manner as the previous ones, and it will be seen that the upper slide has an angular motion, with a curved slot and screw for the production of tapering and angular work. The tool-holder in this case has four screws, arranged one at each of the corners of a square plate. This plate is not movable, as the last was, around a central pin, but is firmly fixed to form a part of the upper plate. The tool is placed under any two of the four pinching screws, and there is thus a choice of four positions, any one of which may be chosen that the shape of the work may render most convenient. The choice of positions is much more limited than in the last example, and this is no doubt a disadvantage, but the holder is very strong and efficient in all other respects.

At Fig. 27 is shown a strong substantial lathe of modern design, for the execution of tolerably heavy hand-turning in either wood or metals, but chiefly in metals. The massive cast-iron bed is carried by two strong cast-iron standards, which are required to support it steadily. The surfaces where the standards come in contact with the under-side of the bed are planed, and they are bolted together, so that the bed and standards may be as firmly attached to each other as if they were one solid casting. The top surface of the bed also, and the inside edges forming the space between the two sides of the bed, are truly planed up to a smooth surface, so that the screw head-stock may be slid anywhere along the lathe-bed without affecting the position of the line joining the lathe-centres. The driving head-stock is, of course, firmly fastened down upon the lathe-bed, its bearing-surface being planed to fit properly down upon the surface of the bed. The rib projecting from the under-surface of the head-stock, instead of being made to fit nicely between the two slabs of the bed, is sometimes left much narrower, in order that the whole head-stock may be shifted bodily out of the usual line of lathe-centres. This provision, however, is only of use for sliding lathes, or with lathes having slide-rests with fixed slides, as the object of it is that with the tool following its usual course parallel to the proper line of lathe-centres, taper and angular work may be produced instead of ordinary turning. When the head-stock is so constructed two screws are placed through the projecting web, and so as to come across the space between the two planed edges of the lathe-bed, which they accurately fit. By turning these screws in the proper direction the position of the head-stock may be very nicely adjusted to produce any small amount of taper, or it may be adjusted to the slide-rest for producing a flat surface or a parallel shaft. Of course this arrangement is not required for lathes intended solely for hand-tool turning, nor for such as have slide-rests with shifting slides. With the first the shape of the work would be quite unaffected by the position of the lathe-spindle, and with the second the taper can be produced by shifting the slides, and without shifting the head-stock. The cone-pulley of this lathe has five speeds, and is adapted to receive a flat leather belt and to drive from a shaft overhead. The speeds may be still further varied by the double-gearing, in the manner previously explained. The small hand-tool rest shown in place upon the bed may be removed, and a slide-rest substituted, when the nature of the work renders it advisable.

PRACTICAL APPLICATION OF THE FINE ARTS.—XI.

THE ART OF MOSAIC (*continued*).[1]

By P. H. Delamotte, Professor of Drawing, King's College, London.

In the practical application of fine art to mosaic, we must use those canons of art which are universally true, modifying these according to the material in hand. Of course, designs for the decorations of walls will be different from those for floors. The Romans certainly did put much good work and beautiful pictures upon the floors, much as we see handsome carpets now-a-days with bunches of flowers and even landscapes portrayed upon them. Still we suppose that scarcely any one could put his heavy boot upon the Cirencester Ceres or Flora without a pang; if his taste did not feel it, he would deserve a twitch of gout to remind him of what he ought to consider. It would be very inconvenient to be continually jumping about to avoid pressing an unhallowed heel upon some fair production of nature: we cannot, therefore, admit the representation of natural objects upon a floor intended for general traffic. It remains for us to discuss the character of designs that are admissible; and our choice is limited to colour and form.

In form we cannot do better than go back to the simplest patterns and the most classical models. The common Grecian border (Fig. 23, Cirencester), either in its ordinary form or as we have it here, is an unfailing source of pleasure to the eye. Another very common border, very convenient from the possibility of turning or stopping at almost any point, is the twisted cable, as shown in Fig. 22. The Grecian is slightly altered, by being adapted to what might be almost called oblique co-ordinates, and enclosed in a diamond-shaped compartment in the pavement from Threadneedle Street (Fig. 26). In this relic we have, too, another very common design, the endless knot, whilst square compartments are mingled with diamond-shaped ones, rhomboids affording a pleasing variety of oblique, acute, and right angles. In this, too, we have idealised flowers and leaves of two kinds. The endless knot and some of the other ornaments occur again in Fig. 25, from Cirencester, combined with some other very felicitous forms. The arrangement of eight rhomboids around a point in a shape somewhat approaching both a cross and a star, is very happy; and the introduction of regularly curved lines in the terminal border breaks the monotony of so many straight lines with no greater curves than those of the endless knot. In this example the cable is coloured on the inner side of a brownish-orange, whilst the two outer rows of tesseræ are nearly white; the same colours and arrangement hold good of the endless knots. The diamonds are separated by black lines; the interior of all of these are yellow; whilst the line immediately round the interior is black and orange in alternate diamonds, white coming again between this and the black.

In Fig. 20, from Abbots Ann, Hampshire, we have scarcely more than the idealised leaves of the former figure carried out a little further, and more idealised, and more geometrical; and in Fig. 21, within a similar border to some of the former, a more complicated figure is introduced, still, however, mainly founded on the cross and circle.

The next kind of ornament that we meet with is of a somewhat different character. It consists no longer of mere geometrical lines, straight and curved, adapted more or less to pleasing shapes, and sometimes approaching the form of idealised flowers and leaves; but we have now in such patterns as that from Cirencester (Fig. 24), and from Woodmanchester, in Gloucestershire (Fig. 19), the scroll-work of which the main foundation is the imitation of leaves and branches; still, of course, thoroughly idealised. This style of ornamentation can at the present day be carried into far higher perfection than was the case under the Romans, since the experience of so much mediæval and renaissance work, though the latter may be considerably overcrowded and redundant, has contributed greatly to a just taste in such designs. Too much cannot be done in this direction, where the material in hand will admit of adaptation to this use. This will be the case especially when natural materials or *smalti*, as the small pieces of glass are called, are employed. These *smalti* are fragments of glass broken off larger cakes of six or eight inches long by four or five wide, and of a tolerably uniform depth of nearly half an inch. These broken pieces, of course, are not quite uniform in shape, so that the form can be chosen which is best adapted to the pattern in hand, whilst for flat surfaces the pieces most nearly approaching regular cakes are preferable. But if terra-cotta or other forms of clay manufactured in the shape of small tiles are employed, it will most naturally happen that these fall into regular geometrical patterns. Of course, where the subject is large, and the tiles employed are very small, and both cubical and triangular, a very near approach can be made to either a scroll pattern or an imitation of natural objects; but after all this is rather adapting a somewhat unwieldy material to a purpose alien from the best use of ornament, which consists in applying the material to the most pleasing effect of which it is naturally capable.

When the surface to be covered is a wall or piece of furniture, there is then no reason why a picture should not be imitated. Thus the great churches of Italy have their walls decorated, and these copies of the masterpieces of great painters carry to posterity a very close approximation of the original works unimpaired by the passage of time. We say a very close approximation, because however accurately a great work is copied—and the Italians are certainly great copyists in the best sense of the word—a copy can never convey the whole grace and beauty, and thought of the original, unless the hand and heart of the master be employed upon the copy, when, of course, it becomes no longer a copy.

But even of pictures, some are more suitable to this style of material than others. To a great extent the subjects suitable for fresco painting are also adapted for representation in mosaic. A study of great works in the various churches in Ravenna, of which photographs have been taken, will show the character of work which the early workers in mosaic thought best adapted to their material. Here we have the calm, placid figures represented in a dignified repose, such as one might expect would be consonant with the feelings of the descendants of the Greek sculptors of old. No excited emotions, but a calm dignity of feeling—not absolute rest, but a position of motion temporarily and naturally suspended; these characteristics lend themselves agreeably to the means in the artist's hand.

It is not granted to every one to have the means of studying the best models, nor is it by any means in the power even of those who ardently desire it, to design great works of art; but that is no reason why all who make attempts in any branch of art should not place before themselves the highest attainable model, and strive to the best of the ability they may happen to possess to approach as near perfection as possible in the works they take in hand. The constant exercise of all one's powers must lead to increased facilities and capabilities, and thus the hand, the eye, the taste, and the knowledge become expanded and strengthened, just as under the judicious training of a gymnast the muscles of the body gain both strength and rapidity of motion.

TECHNICAL DRAWING.—LXVII.

DRAWING FOR STONEMASONS.

THE MANNER OF LAYING BRICKS—THE TERM "BOND" DEFINED.

In building with bricks, as all the parts are equal and regular, they are laid in horizontal courses from the foundation upwards. The reason is obvious · regular bodies, such as bricks placed on a horizontal base and with vertical sides, have no tendency to move laterally. If, on the contrary, bricks were laid on an oblique base, they would have a tendency to slide downward in one direction. Hence the wall might eventually bulge or crack, or lose its perpendicularity.

If we suppose a wall of only half a brick thick, all the bricks used would of course be laid lengthwise, so as to show their whole length in the face of the wall, in which case they are called "stretchers" ("Building Construction," Vol. I., p. 141).

In laying a second course of bricks, care must be taken to prevent any two vertical joints from coinciding. This would be effected by placing the joints or meeting of the ends of the second course of bricks over the middle of the bricks of the first course. The same arrangement would be attended to in the third and in all the succeeding courses.

Fig. 533 is the plan and Fig. 534 is the elevation of part of a brick building in which the walls are supposed to be half a brick thick—that is, 4½ inches—and built in the manner just described.

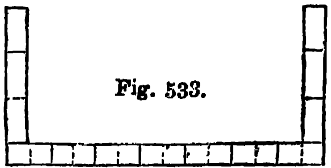
Fig. 533.

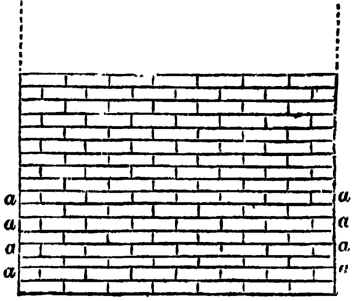

Fig. 534.

This arrangement of never allowing any two vertical joints to coincide is technically termed "breaking joint," and a wall thus built is said to have a proper bond—a term which implies that the parts are properly connected.

It will be observed that all the bricks represented in the elevation are stretchers, showing their whole length in the surface of the wall, excepting one brick at the angles of the wall in each alternate course, *a*, *a*, *a*, *a*, which shows itself in the elevation. A brick thus laid is called a *header*.

By this method of placing a header at the angle of each alternate course, a "bond" is obtained. If the whole were laid in stretchers throughout, as in Fig. 535, all the vertical joints would coincide, and the wall would only consist of upright piles of bricks, the entire weight of each pile resting on one brick below, and there would be no connection between the upright stacks but the mortar in the vertical joints, which would, of course, be insufficient to prevent either one from separating. This has been fully explained in lessons on "Building Construction."

It must be mentioned that the above example is introduced merely as an illustration of the necessity for correct bonding of the bricks; but walls of half a brick thick are not used in any proper building, being far too weak to afford the necessary stability even to the smallest buildings, unless the brickwork be held together by a wooden frame, of which it fills the intervals. This style of building, used for economy, is altogether unsuitable for public buildings, unless of a very temporary character, and is called *brick nogging*, specimens of which are seen in many villages.

Brick nogging is sometimes used for partitions in dwelling-houses.

All proper walls, then, are one-brick thick and upwards, and it is to be observed that in such, bond cannot be obtained without introducing parts smaller than a regular brick near each angle or opening—that is to say, not only at the corners of the walls, but also at each side of every door, window, or recess throughout the whole building.

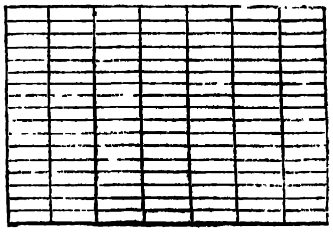
Fig. 535.

For instance, if we suppose a wall to be one brick (that is, about 9 inches) thick, the bricks may evidently be laid either as *headers*, in which case one brick laid across, front to back, occupies the whole thickness of the wall; or as *stretchers*, in which case two bricks laid alongside of each other in the direction of the length of the wall make up the thickness.

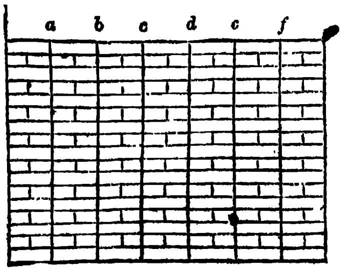

Fig. 536.

Now if we suppose Fig. 536 to represent the elevation of a wall in which the bricks are all of the regular full size, and laid headers and stretchers alternately and in successive courses, it will be evident that one-half of all the vertical joints, *a*, *b*, *c*, *d*, *e*, *f*, must necessarily agree, because every two headers occupy in the face of the wall precisely the same space as one stretcher, and the effect would be practically the same as that shown in Fig. 535—namely, the wall would be formed of mere stacks one brick wide.

To obviate this inconvenience, which would render the bond very imperfect (since, although the vertical stacks are bonded together by the bricks of which they are formed crossing each other, it has been shown that they are only united by the mortar), small headers, only a quarter of a brick in width, are used near each angle, opening, or break in the wall, as was before mentioned, the utility of which will be evident on comparing Fig. 537, in which this method is represented, with the preceding figure.

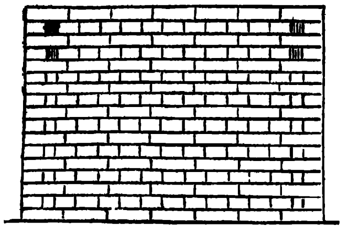
Fig. 537.

In this figure, some of the small headers are shaded, in order that they may be better visible. They are technically termed *closers*, and are further described and illustrated in lessons in "Building Construction."

On examining any brick building the student will at once see that this arrangement is generally followed, and thus a perfect bond is produced throughout the whole wall, it being observed that these narrow bricks appear in alternate courses only, and are the second brick from the angle of their respective courses, the first or corner brick of the same course being always a header.

Broken bricks are generally called brickbats; but the term *bat* is by workmen specially applied to the one half of a brick broken across the middle.

A regular bat, or half-brick broken a second time, produces two pieces, each a quarter of a brick in width and half a brick in length, which combine to form a closer. These pieces singly are called *half-closers*. When a brick is broken transversely into two unequal parts, the larger of the two is called a *three-quarter bat*.

The remarks hitherto made upon the bond of brickwork apply only to the external surface of the wall, as seen in elevation, which may be judged of by the eye. In walls of certain thickness, the internal bond, which cannot be seen or examined after the work is finished, is of equal importance.

Fig. 538 represents the section of a wall two bricks in thickness, in which the courses are supposed to be laid alternately, all headers and all stretchers, so as to correspond with the foregoing elevation, and yet, owing to a faulty arrangement of the bricks used, all the vertical joints in the middle of the wall coincide with each other. It will be evident that such a wall, although it would appear strong and perfectly bonded if the external surfaces only be examined, has no proper bond internally, for one vertical joint prevails from top to bottom, and from one end of the wall to the other; so that such a wall would be liable to split in two by a longitudinal fracture.*

By adopting a different arrangement, as in Fig. 539, which represents the section of a wall of the same thickness, the above defect will be completely obviated, for it is evident that all the vertical joints, internal as well as external, are now perfectly broken, and that a sufficient bond is thereby obtained throughout every part of the wall.

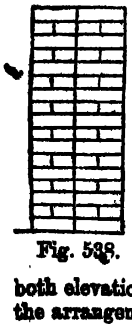
Fig. 538.

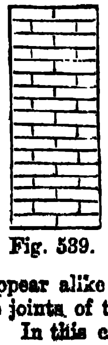
Fig. 539.

It will hereafter be seen that it is often convenient, if not absolutely necessary for the purpose of obtaining the most perfect bond, to finish one side of a wall, not exactly, although nearly, in the same manner as the other, so that although both elevations may appear alike to an inexperienced observer, the arrangement of the joints of the one will in reality be less regular than the other. In this case the *face of the wall*, which in a building implies the external surface, being that exposed to view, must be finished in the most regular manner, in preference to the *back* or internal surface of the wall, which is eventually (at least in most cases) concealed from view by plastering or papering.

Having thus defined the term "bond" in general terms, and having entered into the subject at some length in lessons on "Building Construction," it is now proposed to give further instruction on this all-important branch of the bricklayer's work. In doing this, it may be necessary to repeat some few paragraphs or illustrations from the lessons on the general subject, with the view of showing their intimate connection with the present course of lessons. The student is urged to make himself thoroughly acquainted with the subject as a whole before proceeding with further detail. It is not, however, sufficient to read, even though that reading be accompanied by drawing: the instruction must be *realised*, and for this purpose a number of wooden bricks should be provided. These can be obtained from any carpenter, and may be of any convenient size, so long as the true proportions are kept up. About half the real size will be found best adapted for class teaching, whilst for private study quarter size will be sufficient. Amongst these model bricks should be bats (or half-bricks), closers (or bricks cut in half lengthwise), and also a few quarter-bricks.

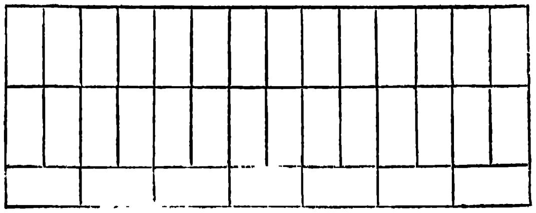
Fig. 540.

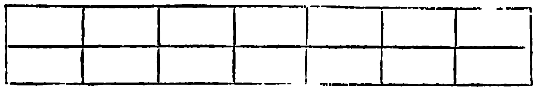
Fig. 542.

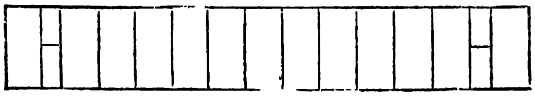
Fig. 543.

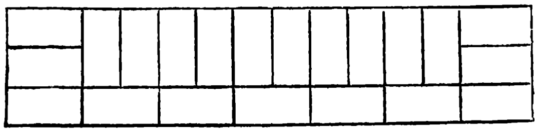
Fig. 545.

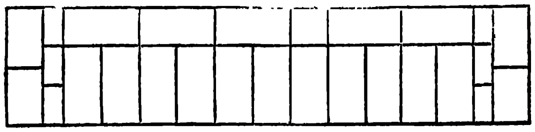
Fig. 546.

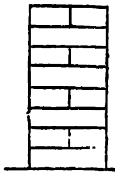
Fig. 544.

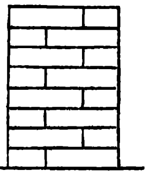
Fig. 547.

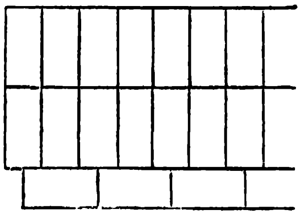
Fig. 541.

With these the walls of different kinds and thicknesses, in two or three courses, should be built according to the instructions here given. The drawing will then be intelligently made, whereas it would otherwise degenerate into a mere copy of straight lines.

DRAWING FROM SOLID OBJECTS.

In all the examples hitherto given, *one surface* only has been shown of each of the subjects under consideration.

Now, for absolutely working drawings this is all that is necessary, such drawings being required to show the exact position of every wall, or of cornice, sill, or step, so that the work may be executed according to the exact measurement of the design.

But if it be required to draw a house or any other object in such a manner that an impression of solidity may be given, further study and practice becomes necessary, and the student is referred for instruction on this head to the series of lessons on "Object Drawing" commencing at page 3, Vol. II. of THE TECHNICAL EDUCATOR.

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

We have in lessons on "Building Construction" given the general distinction between English and Flemish bond, and we now proceed to the further elucidation of the subject, adopting the system laid down by Sir Charles Pasley, R.E.

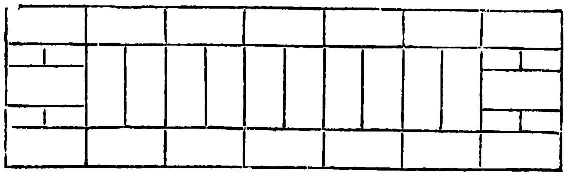

Fig. 548.

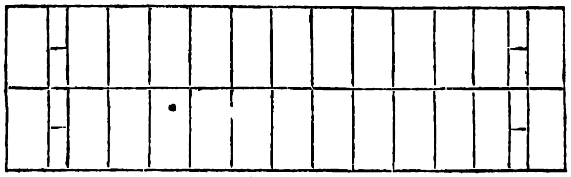

Fig. 549.

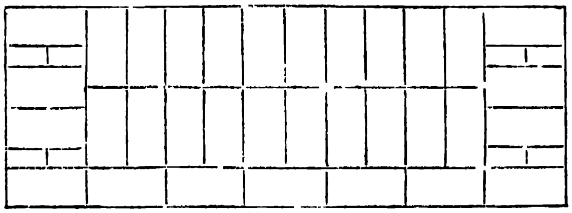

Fig. 552.

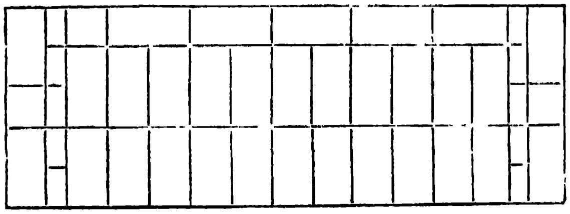

Fig. 553.

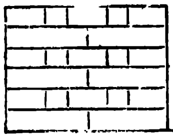

Fig. 550.

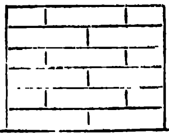

Fig. 551.

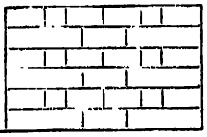

Fig. 554.

COMMON ENGLISH BOND.

In common English bond, alternate courses of headers and stretchers appear on each side of the wall, so that the elevation of it is the same which has already been described in relation to Fig. 537. But with the exception of the stretchers, already mentioned, which appear externally, no others whatever are used, so that the remainder of the wall consists exclusively of headers.

In looking at a wall thus built, those courses where headers appear to the eye, are called *heading courses;* but those in which the stretchers appear, are called *stretching courses*, notwithstanding that the inside of the latter may be filled up with headers.

It is essential in common English bond, that the horizontal joints in each course shall never be broken, but that the bricks shall be so arranged that the whole of the opposite joints shall extend transversely in one and the same right line from one side of the wall to the other—that is to say, the bricks of the same course must always be arranged as in Fig. 540, not as in Fig. 541.

By attending to this rule this style of building will be found extremely simple. In a wall whose thickness is either one brick, two bricks, three bricks, four bricks, or any other dimension involving a whole number, the stretching courses agree on both sides of the wall; but if the thickness be one brick and a half, two bricks and a half, three bricks and a half, or any other dimension involving a half brick, that which is a stretching course on the one side of the wall is a heading course on the other side, and *vice versâ*.

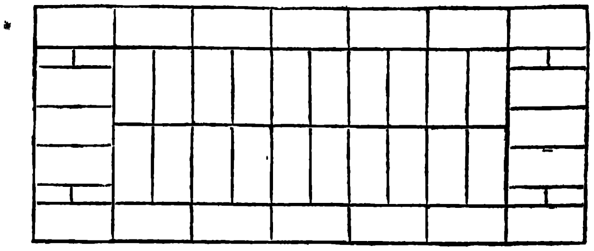

Fig. 555.

In order to exemplify the common English bond thus described in general terms, we will suppose a portion of a brick wall equal to seven bricks in length, and terminating with both its ends at right angles to the general line of the wall. This portion of brickwork may represent part of a wall contained between the openings of two adjacent windows. It is true (says Sir Charles Pasley) that the sides of windows are not now usually finished in such a simple manner; "it was, however, the method used formerly," and we will therefore suppose them to be so for the sake of illustrating the peculiar kind of brickwork now under discussion.

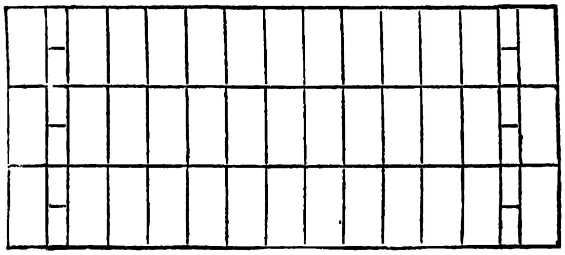

Fig. 556.

Fig. 542 represents the plan of the stretching course and Fig. 543 the plan of the heading course of a wall of this description —one brick thick. In the heading course it will be observed that closers are laid next to the extreme header at each end, without which the proper bond could not be obtained.

Fig. 544 is the section or end of the same wall.

Figs. 545 and 546 represent two successive courses of a wall of the same length, but one brick and a half thick; and Fig 547 is a section of the same wall.

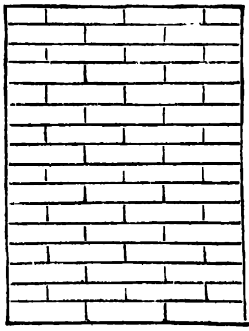

Fig. 557.

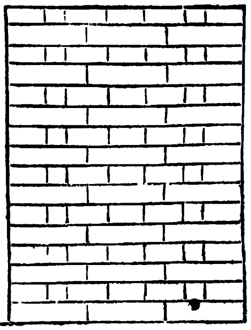

Fig. 558.

In this case it will be seen that, in consequence of there being a half brick in the thickness, that which is the heading course in front is the stretching course in the rear of the wall, and *vice versâ*. At the ends of the wall three-quarter bats are used in alternate courses in order to obtain the proper bond.

In this example, too, it will be observed that the two sides of the wall are not exactly alike, and the same will occur in all walls built according to common English bond, in which half a brick is involved in the thickness of the wall.

Figs. 548 and 549 represent the plans of two successive courses of a similar wall of two bricks thick. On attaining this thickness the ends of the wall present a more considerable surface than in the former examples, and require to have their joints broken by means of a couple of closers in alternate courses, it being necessary to treat the square ends of walls of a certain thickness precisely in the same manner as if they were short portions of the front of a building. Fig. 550 is the section and Fig. 551 the end elevation of the same wall. Figs. 552 and 553 represent the plans of two successive courses of a wall of the same description, but of two and a-half bricks in thickness.

Fig. 554 is the end elevation of the same wall in which a half brick, shown also in Fig. 555, is necessarily used in the centre of each alternate course in order to obtain proper bond.

Figs. 555 and 556 represent in like manner the plan of two successive courses of a wall three bricks thick. Fig. 557 is the transverse section, and Fig. 558 the end elevation.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

VII.—NATIONAL MUSEUMS.

IN my article on Museums at page 358, Vol. II. of THE TECHNICAL EDUCATOR, I have given a theoretical notion or Utopian idealisation of what *the aims* of a national museum should be. I shall now attempt to show how far such ideas may be realised in practice, under conditions which are sure to arise in a great city, that would prove antagonistic to the carrying out in its entirety any such scheme as I have therein suggested.

A review of all the facts connected with such a question are well worthy of the careful consideration of naturalists at the present moment, when through the exigencies of space at the British Museum, it has been determined, notwithstanding the grave objections, hereinafter stated, that have been raised by influential persons to separate the natural history collections from the antiquarian departments and the library of the British Museum, and remove them to a new museum to be erected on a plot of ground on the Gore Estate, on the site of the International Exhibition of 1862.

It behoves all who have any influence to see that the new National Museum of Natural History shall not be cramped in its future development for want of sufficient space; that the architectural arrangements and internal fittings meet the requirements of the day; and that its entire organisation shall be established on a true and proper basis for "arranging, preserving, and exhibiting in a fitting manner a natural history collection worthy of the country as well as of its capital, and intended not only for the special advantage of students and scientific men, but generally for the rational amusement and instruction of all classes;"[*] even whether it should not also embrace the aims of the Museum d'Histoire Naturelle in the Jardin des Plantes at Paris, as defined by the Directory of 1793, viz., "the advancement and teaching of the natural history sciences in all their branches and in their application to the arts and manufactures."

In commencing this inquiry, it is advisable to consider the objections that have been raised to the severance of the scientific from the antiquarian, artistic, and bibliothecal collections. Foreigners regard our British Museum unique as to its aims in collecting under one roof all attainable specimens illustrative of literature, science, and art, so that it may be "regarded as a consulting encyclopædia, a repertory for reference to all these departments of human knowledge."[†] But, nevertheless, while protesting against any breaking up of the present harmonious system, nor failing to notice that while our Parliament year by year, votes supplies for the purchase of additional specimens, it injudiciously does not allow of their proper display, by begrudging money for an extension of the galleries of a museum palpably over-crowded, many of our own countrymen expressed their objections not only on this head, but on the inconvenience that would be experienced if the natural history collections were separated from the scientific books in the Museum library. Others conceived that the natural history collections would be little visited if removed from their present central position to South Kensington, and on this score the severance would prove of especial inconvenience to working naturalists. So strong was this feeling on the question of dismemberment, that the late Sir Roderick Murchison, one of the trustees of the British Museum, declared before the committee that though he had bequeathed to the British Museum the colossal vase of Siberian avanturine granite presented to him by the Emperor of Russia, under the impression that it was the proper resting-place for such an embodiment of science and art, if the natural history collections were removed, it would affect that intention, and he should alter his will.[*]

For many years past Dr. J. E. Gray, as keeper of the Zoological collections, has, in his annual report to the trustees, called attention to the urgent necessity for providing additional space for the natural history specimens, those displayed in the galleries being as far back as 1848 inconveniently crowded, while many valuable specimens and collections were obliged to be stored in the vaults beneath the museums. Thus, in 1816, when Cuvier visited this country, mainly with the object of examining the only known specimen of the skull of the right whale, he had to be conducted by the light of a lantern to the lower regions of the British Museum. If any osteologist of the present day desired to inspect that skull of a right whale in a wrong place, he must descend to the same vault, and examine it by the same light, as in Cuvier's day. Since Professor Owen's appointment as superintendent of the natural history collections he has persistently urged the pressing necessity for additional galleries, or a new museum in some other district, as it was utterly impossible, under the existing state of things, for the officers of that institution to do justice to the national collections, for the proper keeping of which they are responsible to Government.

In 1858 both the trustees and the Government officers seemed to fancy that the only satisfactory way out of the difficulty was by providing a new museum for the natural history collections, and availing themselves of the space left vacant for the equally pressing wants of other departments; Professor Owen being requested to submit an estimate of space required, and a plan for a new national museum of natural history. This he laid before the trustees March 16th, 1859, including therein modifications of his scheme, to suit ground immediately adjoining the British Museum, or a site on the Gore estate *now* occupied by the west galleries of the International Exhibition, and the machinery sheds in Prince Albert's Road. Meanwhile a memorial had been forwarded to the Chancellor of the Exchequer by nine of our leading naturalists—viz., Bentham, Harvey, Henfrey, Henslow, Lindley, in the interests of botany; and Busk, Carpenter, Darwin, and Huxley, in those of zoology—dated November 18th, 1858, requesting a full consideration of the requirements of naturalists before any scheme or re-organisation was finally decided on, and stating their own convictions as to the arrangements best adapted to meet the twofold object of the advancement of science and its general diffusion among the public; and to show how far the scientific museums of the metropolis and its vicinity, in their present condition, answer their purposes, and to suggest such modifications and additional arrangements as appeared requisite, and to render them more thoroughly efficient. The opinions expressed in this memorial may be summarised by specifying the museum deemed necessary to meet the above stated object:—

1. A general and comprehensive typical or popular museum, in which all prominent forms or types of animals and plants, recent or fossil, should be so displayed as to give the public an idea of the vast extent and variety of natural objects, to diffuse a general knowledge of the results obtained by science in their investigation and classification, and to serve as a general introduction to the student of natural history.

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[*] See the "Treasury Minute" quoted in Panizzi's letter to the superintendent and keepers of the Natural History Departments, March 6th, 1862, Parliamentary Papers, 1864, Vol. XXXII.

[†] *Vide* Report of Select Committee on the British Museum, Parliamentary Papers, 1860, Vol. XVI.

[*] Since Sir Roderick's death this magnificent specimen of avanturine granite and work of art has been transferred to the Museum of Practical Geology, of which he was Director.

2. A complete scientific museum, in which collections of all obtainable animals and plants and their parts, whether recent or fossil, and of a sufficient number of specimens, should be disposed conveniently for study; and to which should be exclusively attached an appropriate *library*, or collection of books and illustrations relating to science, wholly independent of any general library.

3. A comprehensive economic museum, in which economic products, whether zoological or botanical, with illustrations of the processes by which they are obtained and applied to use, should be so disposed as best to assist the progress of commerce and the arts.

4. Collections of living animals and plants, or zoological and botanical gardens.

As zoologists and botanists, the memorialists offered no opinion as to the best disposition of the valuable mineralogical collections in the British Museum, and the economic collections in the Museum of Practical Geology.

The memorialists suggested that all the zoological collections with a select zoological library, together with a typical or popular museum of botany, for the convenience of those resident in the metropolis, should be placed under one direction, while the herbaria of the British Museum should be consolidated with the Kew collection, and be removed to a permanent building to be provided for their accommodation at Kew, and these, with a select botanical library, should be placed under one direction. That the directors of the Zoological and Botanical Museums should be directly responsible to one of Her Majesty's ministers for the proper management of the several departments. That the Museum of Economic Zoology at South Kensington should be further developed, and that the Museum of Economic Botany should be retained at Kew. That the existing collections should be separated into popular typical and student's scientific collections, and that while the former should be accessible to the general public every day in the week, the latter, with their respective libraries, should likewise be daily available to students of zoology and botany only. The economic and living collections should be available to the general public. The Typical and Economic Museums should be fully displayed in spacious galleries, in large buildings, in light, airy, and accessible positions. The scientific collections for the special use of working naturalists need only occupy small space in convenient studies, and be so arranged as to allow of the specimens being taken from their receptacles for direct examination.

This memorial, in connection with Professor Owen's estimate of space and plan for a new national museum of natural history, led to the election of the Select Committee of the House of Commons of 1860 to ascertain the requirements, created by the necessity for an increase of space, of the British Museum, and to the introduction of a bill to empower the trustees of the British Museum to remove the natural history collections, and other objects to any suitable place, notwithstanding the pressing necessities of the case as stated by Professor Owen, Dr. Gray, and other keepers of the natural history collections, as given before the committee, in correspondence between the Treasury and the trustees and their officers, and in the report of Professor Owen and the keepers of the Natural History Departments, March 16th, 1862. This bill was thrown out on the score of expense at the debate on the affairs of the British Museum, May 19th, 1862. It is amusing to note how thoroughly unconversant men of education and of the highest political status can be in regard to the requirements of science, and with the unity of natural history classifications. In his estimate and plan of March 16th, 1859, Professor Owen pointed out the necessity of acquiring skins and skeletons of the whale tribe, as illustrative of the greatest bulk attainable in the present epoch, and as one of the peculiarities of the Mammalian class, especially as the largest species, the right whale (*Balæna Mysticetus*) may become extinct, through its extensive slaughter by whale fishers, for the Museum only possessed the skull previously referred to, stowed away out of sight in the cellars. Further, he had estimated the length of the skeletons of the right whale at 95 feet, sperm whale 75 feet, bottle-nose whale 40 feet, grampus 30 feet, finner whale 20 feet, but by reason of their vast size such specimens, which would be of the greatest value to the naturalist, he could only expect to find accommodation for in "a national museum." He estimated the length of gallery for the *entire* Mammalian series at 850 feet. In the debate Mr. Gregory, who opposed the bill, exclaimed, "850 feet for the exhibition of whales!" in the same vein as Dominie Sampson gave vent to "prodigious!" Viscount Palmerston in his speech said, "Let me propose a compromise to my honourable friend: let him, when the House shall go into committee on the bill, introduce a clause prohibiting any whales. I have no doubt whales are objects of great interest, but sooner than go to the expense of paying £50,000 when we can get land for £10,000 an acre, I for my part shall be willing, with my honourable friend, to exclude whales altogether from disporting themselves in Kensington Gardens." This was said in all earnestness, and not, as might be supposed, in a spirit of banter.

In his plan of 1859, Professor Owen was understood to express a conviction that in a national museum the whole series of natural forms should be fully displayed to public gaze. Professor Flower, in commenting on this idea, observes:—

"Let the reader imagine what a public library would be if the books, instead of being shut up and arranged on the shelves for consultation when required, had every single page framed and glazed and hung on the wall, so that the humblest visitor as he passes along the galleries has only to open his eyes and revel in the wealth of literature of all ages and all countries, without so much as applying to a custodian or opening a case. There is something truly heroic in the conception of such a scheme; but laying aside all questions of space and cost, what would be its real utility to those who are able to appreciate and make true use of its contents! All the inconveniences, all the impossibilities, I may say, of a library arranged upon such a plan would be found in a museum containing anything like an adequate number of objects for the purposes of really enlarging the boundaries of scientific zoology, in which every specimen contained in it were exposed to the gaze of all who choose to enter its walls" ("Nature," May 26, 1870).

In the leader of *The Times* of May 21st, 1862, commenting on the debate of the 19th of May, the writer observes—"Let Mr. Owen describe exactly the kind of building that will answer his purpose, that will give space for his whales, and light for his birds and butterflies. The House of Commons will hardly, for very shame' sake, give a well-digested scheme so rude a reception as it did on Monday night." But this Professor Owen had already done, not only in his revised estimate given in his report of March 6th, 1862, but in a lecture given at the Royal Institution, April 26th, 1861, fully reported in the *Athenæum* of July 27 (*et sequitur*), afterwards reprinted in a separate form, which reached a second edition in 1862,[*] and is now out of print. In that work Professor Owen enters fully into the various considerations that should guide the curator to a proper estimate of the requirements of all the great divisions of the three kingdoms of Nature. Therein he says, the first principle in the arrangement and allocation of such objects is, that each class should receive its due proportional amount of elucidation to the extent which the acquired specimens of a museum at the time may admit, and according to the degree in which the principle of variety is manifested in the class. "A museum of Nature does not aim, like one of art, merely to charm the eye and gratify or improve the sense of beauty and of grace." Many forms accord with our apprehension of the beautiful, such as richly plumaged birds, pearly shelled mollusks, brightly painted insects, branched corals, drooping fronded ferns, stately palms, gorgeous flowering plants, and glittering minerals. But there are other forms of unwieldly bulk, or repulsive aspect, that equally claim the study of the naturalist. "What then is needed for a co-equal or justly proportional representation of all the classes of animals (plants and minerals), to the extent in which a nation may possess or have opportunities to acquire the specimens of them?" First and chiefest, adequate exhibition space: how is this to be estimated? *First*, by the number of known species of the class; *secondly*, by the extent of exhibition space occupied by the proportion of the class which may be properly exhibited in any existing museum; *thirdly*, by the proportion of examples obtained, but not exhibited; *fourthly*, by the ratio at which such specimens have accrued in a given number of years; *fifthly*, by the circumstances or conditions on which the ratio of future increase may be computed. Such requisite data I have as far as possible gleaned from the work of Professor Owen, and the various reports, etc., previously referred to and tabularised, not only for the purpose of saving space, but that the whole of such data may be taken in at a glance, for facilitating comparisons.

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[*] "On the Extent and Aims of a National Museum of Natural History." By Professor Owen, F.R.S.

DATA AND ESTIMATE OF SPACE FOR THE NATIONAL COLLECTION OF NATURAL HISTORY.

	DATA, 1862, SUPPLIED BY EXISTING MUSEUM.							ESTIMATE FOR NEW MUSEUM.		
DEPARTMENTS.	NUMBER OF KNOWN SPECIES.	NUMBER OF SPECIMENS IN PRESENT MUSEUM.	NUMBER EXHIBITED IN PRESENT MUSEUM.	NUMBER IN STORE, STUDIES, &C. AT MUSEUM.	PRESENT LENGTH OF GALLERIES. FEET.	SUPERFICIAL AREA OF EXISTING GALLERIES, ETC., IN SQRE. FEET.	RATIO OF INCREASE OF SPECIMENS PER ANNUM.	LENGTH OF GALLERY. FEET.	WIDTH OF GALLERY. FEET.	AREA IN SQUARE FEET.
E 1 Ethnology . . .	30	500	—	500	—	—	33,077	150	50	7,500
Mammalia . . .	3,500	5,300	3,525	1,775	220	11,505		850	50	42,500
Aves	8,300	25,000	12,000	13,000	300	14,550		800	40	32,000
Reptilia . . .	2,000	7,000	910	6,090	70	2,330		300	40	12,000
Pisces	8,000	19,000	1,913	—	70	3,100		400	40	16,000
* 1, Osteology . . .	—	2,200	200	2,000	—	2,900		1,250	50	62,000
Mollusca . . .	16,000	140,000	100,000	45,000	278	14,200		300	50	15,000
Articulata . . .	220,000	—	—	—	70	3,100		250	50	12,500
Radiata. . . .	—	7,000	4,074	2,926	70	5,980		250	50	12,500
† 1, Embryological and Developmental Models	—	0	0	0	—	—		—	—	—
B 1, British Zoology .	—	—	—	—	—	2,550		—	—	--
Zoological Studies, Workrooms, etc.	—	—	—	—	—	2,235				
						62,450				
Botany . . . B 2, British Botany	213,000	—	—	—	80	5,500	—	200	40	8,000
Botanical Studies	—	—	—	—	—	—	—	—	—	—
2 * Palæozoology 3 * Palæphytology † 2 Stratagraphical Geology. Geological Studies	—	153,000	50,000	103,000	370	18,500	7,242	850	50	42,500
Minerals B 3 British Mineralogy Meteorites	652 — 294	50,307	30,000	20,307	247	12,150	3,000=6ft of gallery lngth per annum.	600	40	24,000
† 3 Petrology . . .	110	—	—	—	—	—	—	—	—	—
Mineralogical Studies										
* 4 Teratology . .	—	—	—	—	—	—	—	—	—	—
E 2 Geographical Distribution	—	—	—	—	—	—	—	—	—	—
* 5 Library	—	—	—	—	—	—	—	100	50	5,000
Total length of galleries								7,400		291,500
E 3 Elementary Collections, introductory to the General Collections	—	—	—	—	—	—	—	150	150	22,500
E 4 Lecture Theatre.	—	—	—	—	—	—	—	70	70	4,900
R, Apartments for Guardian, Fireman and Doorkeepers	—	—	—	—	—	—	—	80	40	3,200
							Total. .	7,700	—	= 322,100

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* 1, OSTEOLOGICAL specimens would be distributed in the vertebrate classes in the following manner: Additional length of 550 feet to MAMMALIAN GALLERY; 500 feet (with eggs, nests, etc.) to AVIAN GALLERY, and 250 feet between the REPTILIAN and PISCEAN GALLERIES. * 2, FOSSIL ANIMALS and (* 3) PLANTS would be distributed over the RECENT zoological and botanical series, and a STRATAGRAPHICAL COLLECTION that would have to be established. * 4, Teratological Specimens would be distributed over the Animal, Vegetable, and Mineral collections, and are included in the estimate for space. * 5, THE LIBRARY, or at least that portion embracing special descriptive natural history, should be distributed in the studies attached to each class gallery.

† 1, Models, Specimens, etc., illustrating the generative functions, embryological, developmental, and parthenogenetic phases of the several groups, to the extent of at least 500 typical examples, should be distributed in the galleries or studies, as an essential portion of any modern Natural History Museum. † 2 and 3 are essential branches of a complete natural history series, but as yet our National Museum does not include stratagraphical groups of fossils, or a collection of rock specimens.

B 1, 2, 3, comprising British Natural History, together.

E 1 and 2, illustrating the geographical distribution of the varieties of the human race, in connection with the most characteristic animals, plants, and representative species of the various geographical regions, might judiciously be associated with the Elementary Series, E 3, in the Rotunda of Typical Natural History, as introductory to the general Representative Collections—which building should also contain the Lecture Theatre (E 4) and the Guardian's Residences (R).

MINING AND QUARRYING.—XXIII.

BY GEORGE GLADSTONE, F.C.S.

ZINC.

ORES—ASSAYING—CALCINING—SMELTING—PURIFYING—SPELTER—SHEET-ZINC—VARIOUS USES.

THE ores of zinc which are to be found within the limits of the British Isles do not equal in importance those of some other foreign countries; and accordingly, although the various applications of zinc have greatly increased within the last few decades of years, the home production of the metal has had to struggle against the superior advantages of some of the foreign sources of supply.

Almost every one must be familiar with the Vieille Montagne zinc, which comes here from large works of that name in Belgium. Silesia also used to furnish us with great quantities, and latterly Spain has contributed her rich stores of this metal, while the United States of America are ready to furnish any quantity of the oxide that may be desired.

There are only four descriptions of ore which are of any commercial importance. The first of these, so far at least as England is concerned, is the sulphide, ZnS, commonly called blende on account of its brilliance, or "black-jack" by the miners because of the intense blackness of the crystals. Theoretically it should contain 67 per cent. of the metal, but it is usually associated with a large per-centage of sulphide of iron, and other minerals, to which its black colour is due. It occurs principally in the carboniferous limestone, in the same veins as the sulphide of lead. The two are therefore often mined simultaneously, the blende serving as a subsidiary source of income to the lead mine. The largest home supplies are derived at present from the lead districts of North Wales and of the Isle of Man, but it is also raised in Cornwall, Devon, Derbyshire, Northumberland, and some other places.

Next in importance comes the carbonate, called "calamine" by mineralogists. This used to be in great demand by the makers of brass on the old principle described in the last article; but it is now a comparatively scarce mineral in England, and the competition of the foreign metal has seriously interfered with the working of it. This is the prevailing ore at most of the great Continental works.

Silicate of zinc is very often found associated with the carbonate, and it is considered to produce a very pure metal.

The oxide of zinc occurs in large quantities in the State of New Jersey, U.S., where it is used in the preparation of zinc paint.

When the ore is brought to "grass" it has to be carefully separated from the lead ore with which it is generally mixed, and the two present a sufficiently great difference in outward appearance to enable this to be done at a glance without any fear of mistake.

The blende being thus made into parcels, an assay is taken to ascertain the proportion of metal in the ore. This may be done in various ways. One plan is to precipitate the zinc as a sulphide from an ammoniacal solution, by the addition of a solution of sulphide of sodium of known strength; and the quantity of sulphide of sodium required for the purpose will thus give by calculation the quantity of metallic zinc which was in the solution; and the weight of ore from which this was originally made being also known, the per-centage of metal is easily ascertained. The presence of silver, lead, or cadmium, small quantities of which are often found in the blende, will not affect the result.

Another plan, which cannot be so thoroughly relied upon for exactness, though sufficiently so for most practical purposes, consists in dissolving out the oxide of zinc from a given quantity of calcined blende, by means of carbonate of ammonia, and then ascertaining the loss in weight, which will represent the amount of the oxide contained in the sample taken.

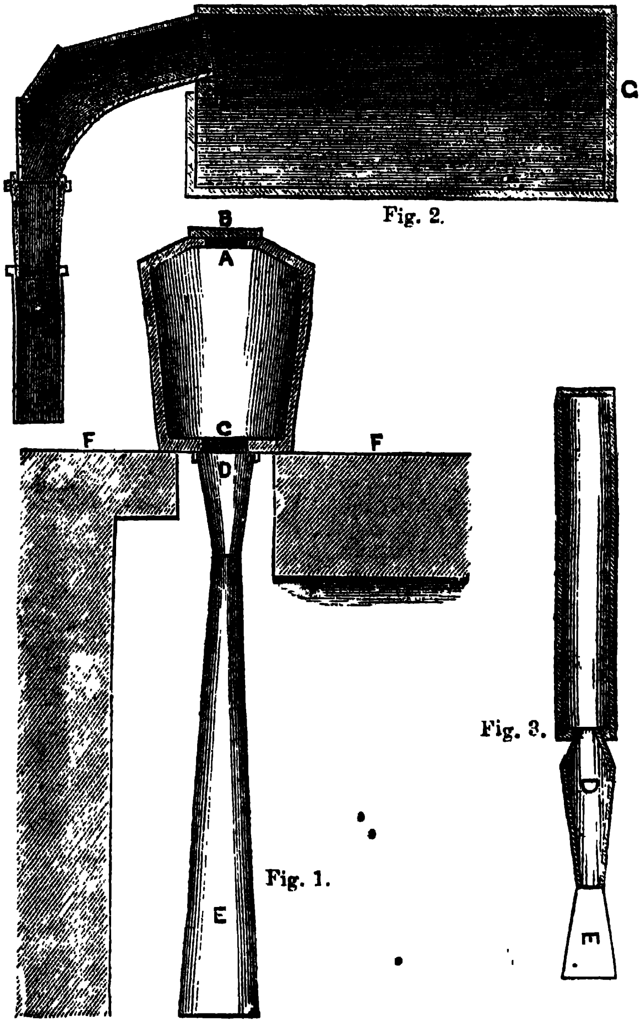

Fig. 2.

Fig. 1.

Fig. 3.

The per-centage of metal may also be ascertained by the loss in weight in fusing the calcined ore in a crucible with charcoal. A certain quantity of the ore is mixed with about one-fourth its weight of charcoal powder, of a quality which will be known to leave a certain weight of ash; and after exposure to a high temperature for about half an hour, the contents will on re-weighing, and making allowance for the ash left from the charcoal, be found to have lost weight; this will represent the amount of oxide of zinc which has been volatilised.

We now come to the processes of reducing the ore to the metallic state. They are generally known as the English, the Silesian, and the Belgian; but they are all one in principle, the differences consisting in the mechanical arrangement. The metal in all cases is distilled out in retorts, of one pattern and arrangement or another.

Preparatory to this, however, the ores are crushed between iron rollers, or ground fine, and washed, so as to separate all earthy matters. Then they are calcined in reverberatory furnaces for about twenty-four hours: the most approved plan of doing this is to have a double-bedded calciner, the one overlying the other, and this may be heated with the waste gases from the reduction furnace. The ore is first dried on the top of the calciner, then allowed to fall through an opening into the upper bed, where it remains from six to twelve hours according to the nature of the ore, during which time it should be well rabbled; after this it is raked through a hole into the lower level, where the heat is much greater, and where the ore remains for a similar period. As soon as the first charge passes forward to the lower bed, a fresh supply is introduced into the upper, so that a constant succession is kept up, and all the heat of the furnace is thus utilised. When blende is the ore used, twenty-four hours is about the time occupied by this process, but calamine will not take more than about one-half.

The next step is the reduction of the metal. For this purpose a series of retorts and receivers are required, and a furnace.

In all the processes referred to, the retorts are made of refractory clay, and are made at the reduction works; but they vary considerably in form. Fig. 1 is a section of the English model, Fig. 2 of the Silesian, and Fig. 3 of the Belgian. The former is a circular pot with an opening, A, in the top, for putting in the charge, covered with a lid, B; and another opening, C, at the bottom, for the exit of the metallic fumes which pass through the pipes D and E into a receiving trough, and condense during the passage. The second is a long narrow chest, flat below and rounded above, with only one opening for all purposes, the pipes D and E for carrying off the fumes being fitted in after the charge is introduced. The Belgian consists of a cylinder of clay, like a drain-pipe, closed altogether at one end, and partially so at the other. The appendages D and E correspond to those similarly marked in the two other diagrams.

In respect of size they differ quite as greatly as they do in form; and this renders a very different furnace arrangement necessary in each case, so as to ensure a proper economy of fuel. An English pot contains a charge of about 350 lb. of ore, a Silesian retort about 70 lb., and a Belgian about 25 lb. It must not be supposed from their names that the former is only used in England, and the others in their respective countries; for pots made in all these countries may be found standing side by side in the same works.

The retorts are made of fire-clay, well worked up with the remains of old pots ground fine, and when sufficiently kneaded the clay is built up on the inside of the mould, and well beaten to prevent the occurrence of any cracks or air-holes, just as in making the pots for the glass works; and when complete they are carefully dried and annealed prior to use.

The English furnace is in the form of a kiln, and is made to contain six pots. These stand on the floor of the kiln, F F (Fig. 1), immediately over a corresponding number of openings which lead to vaulted chambers below, in which (being kept cool) the zinc readily condenses. The pot being in position, and the short pipe D being fixed on, it is now ready for charging. Some billets of wood are placed over the hole at the bottom, upon them a quantity of coke, and then the calcined blende in four separate parcels, alternating with layers of coke. The lid B is then put on and luted down, and the furnace is heated. Presently a brownish-coloured flame issues from the pipe D, which afterwards changes to a light blue, and which is indicative of the zinc commencing to come over, and of the time having arrived for fixing on the long pipe E, to prevent its becoming dissipated. Below this a tray is put, into which the condensed zinc falls in a gentle metallic shower. When the drops succeed each other very slowly, it would involve too great a waste of fuel to continue the operation. The whole is usually extracted in something less than three days from the time of charging, and the result, if an average quality of blende is used, will be about 150 lb. of metal from each of the six pots.

The Silesian furnace is square, with a long narrow fire-grate running through the middle of it, below the level of the floor; with the furnace-door at one end, and the chimney at the other. On each side of the grate, with their backs, G, towards the fire, stands a row of twelve of the retorts shown in Fig. 2, and the flues are so arranged that the fire passes all round and over the twenty-four retorts before entering the chimney-stack; the whole of the retort, down to the junction of the nozzle D with the condenser E, being enclosed within the furnace. In this case each charge is worked off in twenty-four hours. The first four are occupied in raking out the remains of the last, and in re-charging the retorts, during which time the fire is allowed to slacken; it is then got up to nearly a white heat, and maintained at this until the operation is about over. The volatilised zinc passes through the nozzle and the condensing tube into a receiver below, as already described. Each retort yields on an average about 24 lb. of metal.

The Belgian furnace is again quite differently arranged. As many sometimes as ninety of the little retorts (Fig. 3) are arranged in rows one above another, the front of the furnace being furnished with a series of shelves, with a corresponding notch at the back for them to rest upon; the fire-grate is immediately below, and the heated gases pass between all these rows of retorts before reaching the flue at the top which leads to the chimney. The spaces between the retorts in front are filled up with clay, to prevent the escape of the heat in that direction; the back of the furnace is solid. They are often built back to back, as a matter of economy. The retorts are charged every twelve hours, and the lower ones, being exposed to a much greater heat than the upper rows, receive a much larger charge than the latter. The zinc is not only condensed, but also collected in the receiver E (Fig. 3), the end of which is nearly closed for that purpose.

The rough zinc obtained by these several processes has to be re-melted, to be purified and made into cakes. This is done in iron pots; the zinc is well stirred, and the scum which floats upon the surface is carefully skimmed off, after which the metal is poured into moulds. If it should contain any lead, it is allowed to stand for some little time until it cools down to near the solidifying point of zinc, when the lead will collect at the bottom of the pot.

Cadmium is very generally to be found in the rough zinc, but it is easily separated, as it is a highly volatile metal; and all that is necessary, therefore, is to keep the zinc in a molten state for a sufficiently long time in an open furnace.

Metallic zinc in cakes or ingots is known commercially under the name of spelter, and as such it is largely exported to India and elsewhere.

It was only about the beginning of the present century that it was found possible to roll zinc into sheets, because it is highly crystalline, and only possesses a slight degree of ductility. It is brittle under the hammer both at the ordinary temperature and at 400° Fahrenheit, but between the boiling-point of water and 300° Fahrenheit it is sufficiently tenacious to be rolled out into sheet or drawn into wire. This discovery was of no little importance, as the value of zinc is so moderate as compared with the other metals which could be treated in the same way. Accordingly, sheet zinc is now very largely used for roofing, and making gutters, spouts, and pipes; and it has this great advantage over copper, that the slight oxidation which soon takes place over the surface perfectly protects the metal below from the atmospheric influences; so that as far as exposure to the weather is concerned, it will remain unchanged for an almost indefinite period. It has also the advantage over lead in that, being harder, a much thinner sheet can be used; and that the oxide does not cause water that is exposed to its influence to become poisonous. For these reasons many domestic utensils are made of zinc, though it cannot be conveniently used for any purpose in which it might be subject to high temperatures. Although the price of the material and cost of fixing is more than double that of the coarse asphalte felting used for roofing purposes, it is far cheaper in the end where durability is required, as the metal will not require renewal for many years, and the constant application of tar which is required to keep the felting water-tight is altogether dispensed with.

The valuable applications of zinc as a constituent of useful alloys have already been described under the headings of iron and brass; but there are several other minor uses which must not be overlooked.

Both the oxide and the sulphate are used in medicine; the oxide is also used sometimes as a substitute for a lead salt in the manufacture of crystal glass, and in colouring pottery.

It is also employed in the place of lead in the manufacture of painters' colours, and it is much to be recommended on account of its harmless character. The oxide of zinc is prepared in America for this purpose on a very extensive scale, by reducing the ore in reverberatory furnaces, and burning the zinc vapour which is evolved, the light fumes from which are carried into a chamber made of canvas which is kept moist, and on the inner surface of which they are condensed in the state of oxide.

As pure zinc melts at about 800° Fahrenheit, and is very limpid, it forms a convenient material for making large castings; the edges and other fine parts will come out very sharp from the mould, so that but little subsequent trimming up will be necessary; and by artificially bronzing it, an agreeable colour can be given to its surface.

There is one very important application of zinc which has been reserved to the last, because it is of a totally different character from the rest—viz., its use in electricity. It is the most electrically positive of all the metals that can be conveniently used, and accordingly it finds its place in every form of galvanic battery that has been brought into practical use, from the original voltaic pile down to the very extensive and elaborate apparatus described in the first paper on the "Electric Telegraph." For the negative pole different inventors have employed various metals, such as copper, silver, platinum, etc., but in every case zinc is adopted as the positive. The metal for this purpose should be as pure as possible, and well rolled, so as to be compact and free from holes, which would tend to an irregular consumption of the metal, and render necessary a more frequent renewal of the plates.

OPTICAL INSTRUMENTS.—XX.

BY SAMUEL HIGHLEY, F.G.S., ETC.

ARTIFICIAL SOURCES OF LIGHT (*continued*).

Photogenic Arrangements.—Before leaving the subject of magnesium and zinc lights, it may be as well to put on record, as suggestive to experimenters, certain chemical means of generating intense lights, which, however, as yet have only been used as lecture-room experiments, and not as practical applications. Thus, by digesting metallic zinc in iodide of ethyl, we obtain a volatile liquid which takes fire spontaneously in the air, and is known to chemists under the name of "zinc-ethyl." It can be distilled in an atmosphere of hydrogen, and if this gas be made to pass through the liquid it will carry off some of the zinc-ethyl, and when ignited will burn with a magnificent white flame. It is probable that ordinary illuminating gas would answer as well as hydrogen for this experiment. The light produced in this way can be employed to take photographs, but its actinic properties are not equal to the effects produced by burning magnesium. Of the same nature is *magnesium ethyle.* Dr. Lyon Playfair made the suggestion to me of dissolving magnesium ethyle in petroleum, and burning it in a suitable jet. As with magnesium and zinc ribbon, white clouds of magnesia would be produced during combustion. Then we have the *chloro-chromic light.* This is produced by passing dry hydrogen, or carburetted hydrogen, through the vapour of chloro-chromic acid, and burning the impregnated gas with a steatite burner. Chloro-chromic acid is easily prepared thus:—Fuse 17 parts of bichromate of potash with 10 parts of common salt, and pour out the mixture upon a slab of cold marble. Break into lumps, and distil with about 40 parts, by weight, of sulphuric acid. Take care that the vapour given off is properly disposed of, and not inhaled, as it is very irritating, though not so much so as bromine vapour. Place the resulting chloro-chromic acid in a small Woulff's bottle, or, what is better, a Woulff's arrangement made out of a capped, wide-mouthed ether bottle, in which a cork fitted with an ingress and egress tube is made to replace the glass stopper when required for use. The ingress-tube is connected with a reservoir of hydrogen, under a sufficient pressure, by india-rubber tubing, in the course of which a chloride of calcium drying-tube is inserted. The ingress-tube should be inserted so as just to reach the surface of the chloro-chromic acid—not deeply inserted in the liquid, to bubble through it, but simply to sweep away its fumes. The egress-tube is fitted with a steatite fish-tail burner, or small incorrodible argand burner, as the fumes attack metal. The chloro-chromised hydrogen burns with an intense white light, which gives off clouds of oxide of chromium; it cannot be burnt for long unless connected with an up-draught. Dr. Monckhoven speaks of burning this flame "in a current of oxygen; oxide of chromium is produced at a very high temperature, and at the same time a flame of such extraordinary chemical power that chloride of silver paper held at a distance of eight inches blackens sensibly in thirty seconds, *or about as quickly as in full daylight.*"[*] Chloride of titanium treated in the same manner gives a blue flame of extraordinary chemical power. In 1863 I exhibited, at a lecture at the Society of Arts, an intensely brilliant and actinic flame, by passing carburetted hydrogen through a long column of bisulphide of carbon vapour, burnt in a flat argand burner four inches wide. Like those previously described, the fumes given off (in this case those of sulphur) were the drawback to its utilisation. As a lecture-table experiment it is very striking.

Bude Light.—In this arrangement oxygen is introduced into the centre of an argand burner, thus replacing the ordinary current of atmospheric air. The argand burner may be supplied with oil or house gas, and the result is a brighter light than is obtained under ordinary circumstances. It is believed that the "oxy-hydric light" recently exhibited at the Crystal Palace is a modification of the bude light arrangement devised and named by Goldsworthy Gurney. Gurney's arrangement also embraced the system of concentric rings of house gas, with strong up-draughts of air brought into contact with each small jet of gas, by means of cones of glass and chimneys, disposed to the best advantage by careful experiment, and large metallic reflectors placed over the chimneys just above the brilliant zone of white light thus produced, so as to cast it downwards. The term "bude light" is, however, usually applied to the first arrangement, where oxygen is made to replace a simple supply of atmospheric air.

Argand Lamps.—In the burner invented by Argand a column of air is introduced into the centre of a lamp flame, and an up-draught created by means of a chimney, the length of which is adjusted to secure perfect combustion. This principle of burner may be arranged to consume gas or liquid. If spirit or oil is consumed, a wick becomes necessary. Wicked lamps may be arranged under two heads—"Suction Lamps" and "Pressure Lamps." Suction lamps may again be divided into two groups, viz., "Simple Suction Lamps," wherein the wick descends to the bottom of a simple reservoir, and consequently the capillary action of the wick has to raise the liquid to the flame from an ever varying level; and "Fountain Lamps," wherein the spirit or oil is raised from a constant level by means of a hydrostatic arrangement of the reservoir. "Pressure Lamps" force the oil (for which this form of lamp is only suitable) by means of a pump, driven by clockwork in Carcel's lamp, and by a rack and coiled spring[*] in the Moderator lamp, to the top of the wick and the verge of the flame in greater quantity than can be burnt, and so cause a constant overflow into the reservoir beneath, which prevents the rapid charring of the wick, and less heat being conducted away from the flame by the metal-work. To increase the liquidity of oil, the reservoir, in the form of a ring, has been placed around and above the burner, as in Parker's and the Sanumbra lamp. To bring the air in more immediate contact with the *exterior* surface of the flame, a thin metal cone has been employed. To throw the air into closer contact with the inner edge of the flame, an inner tube has been inserted in the centre of the argand burner. When a great body of light is required, as for lighthouse purposes, double concentric wicks have been employed. To avoid danger when light hydro-carbon oils are used, a non-conductor of heat—such as boxwood—has been inserted between the metal-work of the burner and the inflammable spirit, as in Young's Vesta Lamp. To prevent an overflow of more than a small portion of liquid in case of a lamp being overturned, an inner wall has been inserted in Silber's simple suction lamp, so as to isolate the mass of petroleum from the wick.

The general principles of construction of argand burners for consuming liquids may be thus summarised under these four heads:—1. A constant and steady supply of oil or spirit at the exact rate of consumption. 2. The means of adjusting the flame to the point of perfect combustion. 3. The adjustment of the interior and exterior currents of air upon the wick, to secure perfect combustion, according to the nature of the substance and the size of the burner employed. 4. The disposition of the reservoir, so that its shape or position shall not interfere with the proper distribution of the light emitted.

Having summarised the general principles of construction of argand burners, I purpose describing a type of each form suitable for hydro-carbon spirit, oil, solid paraffine, and gas.

Hydro-carbon Argand Lamps.—Volatile paraffine oil with a specific gravity of 0·700 to 0·865, heavy paraffine oil with a specific gravity of 0·865 to 0·900, and solid paraffine, the so-called paraffine wax, with a specific gravity of 0·900 to 0·930, the products of the fractional distillation of the crude liquid and tarry matters which come over in the primary distillation of peat turf and bituminous schists, of which the Boghead schist gives the richest yield, and petroleum, the purified natural product of the American coal measures of Ohio and Pennsylvania, give lights of great intensity when burnt in properly constructed lamps. The photogenic oils produced from various sources, and at different temperatures, that figure under different names in the market, though varying somewhat as to chemical constitution, have their specific gravity and boiling-points so close to each other that it is a matter of great difficulty to isolate them, to allow of an examination of their properties. They are tolerably equal as to their photometric value, though I am not aware that any exact photometric comparison has yet been made, or at any rate published.

Though extensively used in America, and the countries of Northern Europe, a strong prejudice still exists in England against the use of paraffine and petroleum oils. This arises chiefly from a dread of the assumed explosive qualities of all mineral oils, and in a less degree on the score of the unpleasant odour given off more or less by these liquids. By a selection of suitable samples, and properly constructed lamps, these drawbacks to their use may be surmounted. Danger can only arise from the employment of mineral oils which ignite at low temperatures, as suitable samples may have a match placed in contact with their surface without igniting, and, if spilt upon a table and floor, would not become dangerous till vaporised by the heat of the room. Danger may arise from improper storage, for if left open to the atmosphere of a small room any vapour arising would mix with the air and form an explosive compound. The sale of dangerous samples—viz., mineral oils having a low boiling-point, the vapour of which inflames below a temperature of 90° Fahrenheit—is forbidden by the Act of Parliament of 1868, except under proper restrictions; nevertheless, care should be exercised when purchasing paraffine oil, as unscrupulous or careless dealers may be met with.* The unpleasant smell is mainly due to imperfectly constructed lamps that do not effect perfect combustion, or to careless trimming and neglect in wiping the oil from the metal burner or reservoir. Again, it may arise from the wick being turned down too low, instead of being adjusted to what may be termed the standard point of illumination of any given lamp, when the flame would neither be too high nor too low for effecting perfect combustion of the material supplied to the wick.

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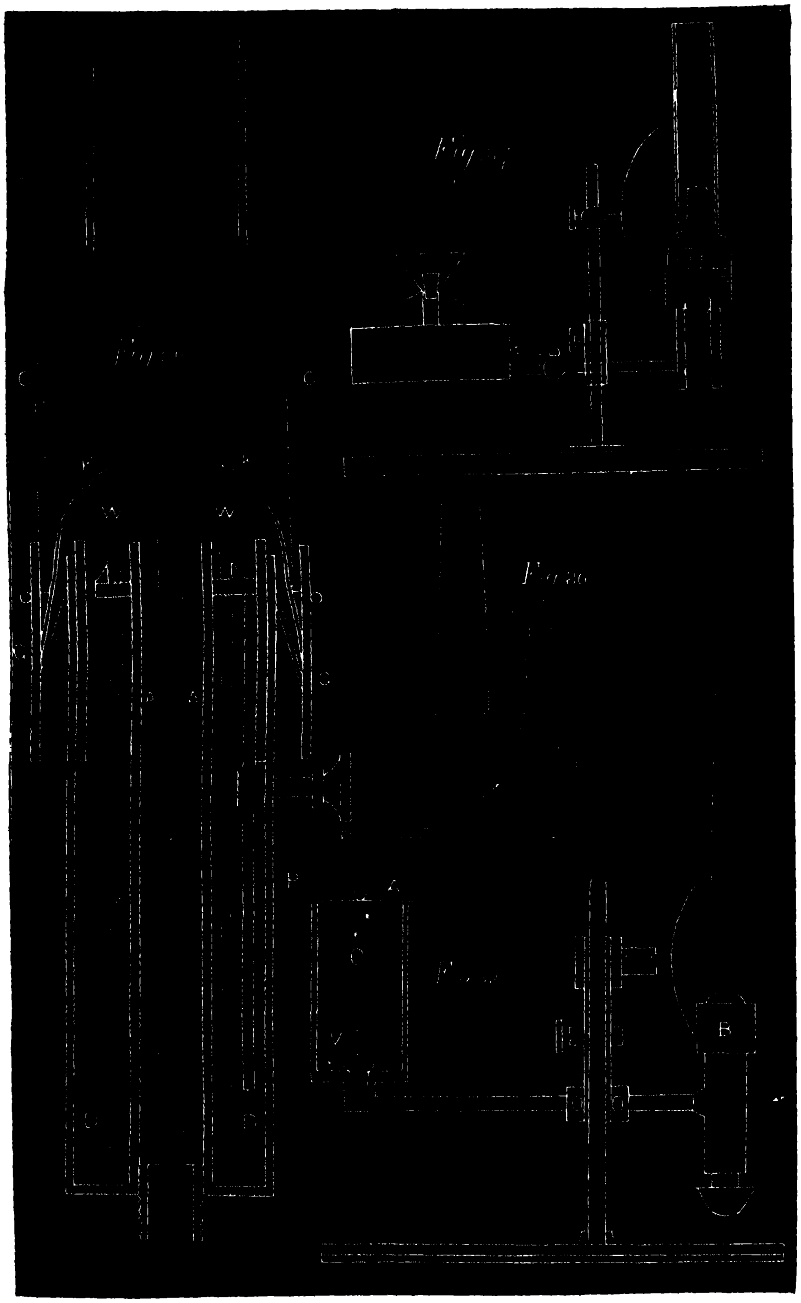
[*] *Photographic Society's Journal*, p. 166. December 19th, 1869.

[*] This is termed, from its inventor, a "Priest-pump."



After trying every kind of hydro-carbon oil that has a character for intensity of light for scientific purposes, I give the preference to refined petroleum having a specific gravity of 0·695, and a boiling-point about 340° Fahrenheit, as it is almost inodorous, and does not give off that greasy kind of vapour that all paraffine oils generate when a lamp is shut up in a lantern for some days, and which bedews the metal-work, saturates the wooden parts, and creates a most unbearable stink when the lamp is again lighted—a smell which is rendered still more unpleasant if, for the purpose of increasing the density of the flame, one ounce of camphor is added to a quart of paraffine, an odour which cannot be covered by the addition of any of the scented essential oils.

Hydro-carbon lamps are used for magic lanterns, photographic self-registering meteorological apparatus, etc. The simplest forms are those of suction lamps, shown in Figs. 86, 87. In Fig. 87 the reservoir, instead of being immediately beneath the wick, is placed behind, so that the mineral oil may not be heated, as the reservoir thus arranged can be placed outside the lantern. It will be observed that in an arrangement of this kind the liquid must ever be sinking to a lower level.

Fig. 88 represents one of the most perfect arrangements, the burner being shown in detail in Fig. 89.

The lamp is adjustable on a rod like that previously described under the head of my "convertible jet." The burner, B, is supplied by a "fountain reservoir," O, the two parts being connected by a brass tube that passes through a boss in the adjusting tube. The reservoir, O, consists of a metal cylinder that has an opening at its lower end, which can be closed by a ball-valve, V. This fits inside an outer cylinder, that is attached to the connecting tube, and acts the part of a funnel to carry the oil from O to the burner B. The reservoir is filled by removing it from the lamp and inverting it, when the oil can be poured into the open mouth at V. The wire that passes through the ball of the valve is then seized between finger and thumb, and pulled up into its socket, when the reservoir is turned over and quickly inserted into the outer cylinder; when the end of the wire of the ball-valve touches the bottom of the tube, the ball is raised, which allows the oil to flow out, an equal quantity of air at the same time rising through the oil to the top of the reservoir, O. As the oil is consumed it sinks below the aperture of the reservoir, when another portion of air enters, and again ejects an equal quantity of oil, which of course finds its level in the receiver of the burner, B, and so, by the automatic action of this "bird fountain" reservoir, a constant level is maintained. To secure a current of air to the immediate neighbourhood of the valve, an air-tube, A, passes from the outer to the inner end of the reservoir, though this may be dispensed with, if the reservoir is made to fit the outer cylinder loosely, to allow air to pass between them to the mouth of the valve at V.

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* In the Schedule to the "Petroleum Act Amendment" of 1868 "Directions for applying the Flashing Test to Samples of Petroleum Oil" are given, and the prescribed apparatus described; but I may state that it has not proved efficient, and an improved instrument will probably be authorised under a new Act of Amendment, wherein a covered petroleum pan will replace the present open arrangement, which allows the vapour as formed to be wafted away by currents of air passing over the exposed surface of petroleum, and so causing the Parliamentary test to be very unreliable. Other improvements will allow of the absolute temperature of the petroleum to be more accurately determined.

The burner is shown in section in Fig. 89. W W represents the cylindrical wick supported in the cylindrical wick-tube, D D, and adjustable by means of the rack-and-pinion arrangement, R P. A small tube, T, is supported in the central air-way by three pins, A A, placed at equal distances on its outer side. The object of this tube is to throw the up-current of air into more immediate contact with the *inner* side of the wick. G G represents the gallery that supports the glass chimney, C C, and a thin metallic dome or cone, K K, that draws the air into more immediate contact with the *outer* side of the wick. The height of the chimney is a very important point in construction, for on that depends the adjustment of the up-draught in such quantity and at such a rate as to secure perfect combustion, for, according to the proportion of carbon contained in the mineral oils, so they require a greater or less supply of air for their proper oxygenation.

If through inattention on this score the volatilised oil is only partially burnt, there will be wasteful consumption of the liquid. The unpleasant odour often noticeable with paraffine oil is frequently due to the same cause. The diameter and height of the chimney influence the size, height, and form of the flame, sometimes contracting it into a cone, and then reducing its illuminating power. With the self-same burner four times the amount of light may be produced, when fitted with a series of unsuitable and suitable chimneys. The point of constant level for the liquid below the top of the wick is a matter of constructive importance. As previously stated, when heavy vegetable oils, such as colza or rape-seed oil, are burnt, the lamp is arranged to bring a constant and overflowing supply to the verge of the flame. Not so with mineral oils: with these the level may be some two or three inches below the top of the wick, as the object in this case is to vaporise the liquid by means of the hot metal of the wick-holder or receiver, and so convey it to the flame in an almost gaseous condition, heated nearly to the point of ignition before it comes in contact with the air that is impinged on the inner and outer side of that flame. The importance of this detail of construction may be judged of when it has been found that by raising the level of the oil an inch or more above the proper point, a decrease of from 30 to 50 per cent. in illuminating power has ensued. The wick best suited for petroleum is a rather loosely plaited cotton; this should be most carefully cut the first time of burning, after which it is better to rub off the charred portion with the tip of the forefinger, then cut off any projecting fibres with a very sharp pair of shield scissors, specially made for lamp-trimming. Petroleum possesses the advantage over ordinary oil that the wick chars very slowly, and consequently gives the standard amount of light for a much longer period of combustion. Like the Carcel lamp, it might be used as a standard source of light for determining the illuminating power of coal-gas and other burners in photometric testing. The pinion P, that raises or depresses the wick W, by its action on the racked support R, should be inserted in the wick-tube a little above the level of the reservoir, to prevent any leakage of that very mobile liquid.

In a paper read before the Society of Arts, Dec. 21st, 1870, Mr. A. M. Silber gave in the following tables the results of some interesting experiments conducted by Mr. Valentine at the College of Chemistry, on burners of the usual construction, and those made according to the principles previously described:—

TABLE I.—Showing Illuminating Power of Original Argand Burners, Consuming Colza and Petroleum Oil.

Description of Lamp. (Argand Burners.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 candles.	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet, for one week's consumption of 42 hours.	Proportional cost of gas and oil.
Colza Oil Lights.				s. d.	d.	
Lamp 1, consuming colza oil from an argand burner, wick $\frac{7}{8}$ to $\frac{15}{16}$ of an inch	11·81	—	1,263	2 9½	—	—
Lamp 2, with imperfect chimney, wick 1¼	3·98	—	532	1 2⅔	—	—
Ditto, with differently constructed chimney	15·01	5	1,775	4 1	9·45	1 : 5·2
Petroleum Oil Lights, as originally constructed.						
No. 1 Burner, size of wick $\frac{7}{8}$ to $\frac{15}{16}$ of an inch	15·67	5·22	864	0 11·8	9·86	1 : 1·21
Do. do. do.	15·47	5·15	787	0 10·7	9·73	1 : 1·11
No. 2 Burner, size of wick same (of French construction)	14·93	4·98	818	0 11·1	9·4	1 : 1·18
No. 3 Burner, size of wick 1¼ of an inch	17·01	5·67	818	0 11·1	10·7	1 : 1·04
No. 4 Burner, size of wick 1½ of an inch	33·85	—	2,145	2 5	—	—
No. 5 Burner, size of wick 1¾ of an inch	38·32	—	3,433	3 10⅘	—	—

TABLE II.—Showing Illuminating Power of Altered Argand Burners, Consuming Petroleum Oil, as Compared with Original Burners.

Description of Lamp. (Argand Burners.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 candles.	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet for one week's consumption of 42 hours.	Proportional cost of gas and oil.
				s. d.	s. d.	
No. 1A Burner, wick	14	4·66	602	0 8·18	0 8·8	1 : 0·93
No. 1 Burner (original) wick $\frac{7}{8}$ to $\frac{15}{16}$	15·67	5·22	864	0 11·8	0 9·86	1 : 1·21
Do. 2nd experiment	15·47	5·15	787	0 10·7	0 9·73	1 : 1·11
Do. (altered)	23·21	7·74	795	2 10·8	1 2·63	1 : 0·738
No. 2 Burner (original), same size as No. 1 (of French construction)	14·93	4·98	818	0 11·1	0 9·4	1 : 1·18
Do. (altered)	21·52	7·17	788	0 10·7	1 1·55	1 : 0·79
No. 3 Burner (original), wick 1¼	17·01	5·67	818	0 11·1	0 10·7	1 : 1·04
Do. (altered)	28·0	9·33	1,102	1 3	1 5·6	1 : ·85
No. 4 Burner (original), wick 1½	33·85	—	2,145	—	—	—
Do. (altered)	46·5	—	2,008	—	—	—
No. 5 Burner (original) wick 1¾	38·32	—	3,433	—	—	—
Do. (altered)	50	—	1,965	—	—	—

From the last column in Table II. we find that for No. 1 Burner (altered) the oil is 35 per cent. cheaper than gas, while for No. 2 Burner (altered) it is 27 per cent. cheaper.

It is interesting to note that the larger argands give, proportionally, less light than the smaller-sized burners—a ratio which is the reverse of that observed in the case of argand gas burners. The central air-deflecting tube exerts considerable influence in correcting this shortcoming in the burners of larger size. The larger burners also consume, proportionally, more petroleum than the smaller burners. This is probably due to the passing of some portion of the oil in the form of incompletely burnt or unburnt vapour through the mantle of the flame.

PHOTOGRAPHY.—X.

By J. C. Leake.

PRINTING IN CARBON.

For many years photographers have been steadily working in order to produce a process which should remove the one great objection to ordinary silver-printing—namely, its want of permanence. Although it is true that prints produced by this process need not of necessity fade, yet it has been proved in practice that it could not be absolutely trusted as to permanence, one print out of a large batch perhaps fading in the course of a few months, while the remainder continued unaltered for years. This want of certainty as to the durability of photographs was of necessity a great drawback to the art, especially where it was applied to purposes of book-illustration, the reproduction of works of art or valuable manuscripts, and was, of course, more important as photographs increased in dimension, and became proportionately more expensive. To such an extent had this difficulty been felt that the sale of ordinary photographs of large sizes had perceptibly diminished, and but for the invention of the system of printing in carbon, would probably have ceased altogether; few persons caring to purchase a picture costing perhaps some pounds, to which was attached a probability of loss at an early period. Hence it had become important, if it was necessary to save the art, especially in its higher branches, to devise some method of obtaining prints which could be relied upon for permanence, and this has happily been most effectually accomplished.

Like all other branches of photography, the perfecting of a carbon process has been the work of considerable time; and many persons have contributed improvements of importance, the latest being those of Mr. J. R. Johnson, whose process, termed the autotype, may be considered as nearly perfection as can be expected for many years to come. Of course there are many processes which vary in detail; but as that of Mr. Johnson is by far the most simple, considering the perfection of the result, as well as from the fact that it offers unusual facilities to the amateur, we shall in this paper confine our remarks to this alone, referring those who may wish for further information upon this matter to one or more of the text-books published upon the subject, especially to Mr. G. W. Simpson's "Printing in Pigments."

Before proceeding to describe the manipulations required in the practice of carbon-printing, it will be well to explain in outline the principles upon which it is founded, and which differ so much from those of the ordinary silver-printing that the operator must abandon these latter at the outset. It has been known for many years that gelatine, after having been impregnated with bichromate of potash, is to a certain extent sensitive to the action of light. This sensitiveness is not manifested in the same way as upon the ordinary silver-sensitised paper, by a darkening of the film, but by the fact that the portion upon which the light has acted becomes insoluble, while that which has been protected from this action remains, like ordinary gelatine, freely soluble in warm water. It stands to reason, therefore, that if a film of gelatine, sensitised by bichromate of potash, be placed under a negative and exposed to light, some portions will be rendered insoluble, while others may be removed by washing in warm water, the result being an image in varying thicknesses of the film; the highest lights, which have been entirely protected, being removed altogether. This, however, would be simply an image in relief, without light and shade, which, although useful in some processes, would not in itself form a picture. In order to form a picture in light and shade, however, all that is necessary is to add to this gelatine some colouring matter, which may be retained by the film in its varying thicknesses; when, of course, those portions which are the thickest will represent the darker portions of the picture, while the lighter parts will be altogether dissolved out, all the intermediate shades being duly represented by the various quantities of pigment retained by the film. This is precisely what is effected in Mr. Johnson's process. A film of gelatine, containing a suitable pigment, is spread upon paper, and is sensitised upon a bath of bichromate of potash. When dry, this pigmented paper is placed under a negative, and exposed to the action of light. Upon removal from the printing-frame the print is attached to a suitable support, during the removal of the unaltered gelatine and pigment. A properly prepared paper is then secured to the film, and this with the film is, when dry, removed from the supporting surface, when the picture is complete and ready for mounting.

One of the chief obstacles to the common adoption of the carbon-printing process, up to this time, has been the difficulty of preparing the layer of carbonised gelatine, which must, of course, be most carefully effected. This, however, need no longer stand in the way, as the Autotype Company are prepared to supply this tissue ready for use at a far lower cost than it could be made by the operator. The pigmented paper, as supplied, consists of a layer of gelatine spread upon paper, and it may be obtained of varying tints to suit the subject of the photograph. The gelatined side of the paper will be found to closely resemble the material known as American leather-cloth, having a dark colour and glossy surface. As supplied, this tissue is not sensitive to light, and in this respect it resembles ordinary albumenised paper. It is prepared in long rolls, and much larger sheets may be obtained than those of albumenised paper. For use it should be cut to the required size before sensitising.

The sensitising solution is prepared by dissolving in common water bichromate of potash, in the proportion of twenty grains of the salt to each ounce of water. A sufficient quantity of this solution is to be placed in a flat dish, when the sheets of prepared paper may be immersed one at a time, taking the utmost care to avoid the formation of air-bubbles. Each sheet should be turned over several times, to ensure a uniform action of the solution, and several sheets may be immersed at the same time. After one or two minutes have elapsed, the whole of the sheets may be turned over in the solution, and the one first inserted then removed and suspended to dry. It is one of the great advantages of the tissue prepared by Mr. Johnson, that this drying may be accelerated by heat, while in many of those heretofore prepared the application of heat simply rendered the film more soluble, and the greatest difficulty was experienced in keeping the pigmented gelatine upon the paper at all, the whole coming off in a sludgy mess, and leaving the paper quite bare.

This difficulty is not likely to occur when Mr. Johnson's preparation is used; but in the case of a tissue such as we have mentioned being met with, we have found that it may be remedied by *floating* the sheets upon a bichromate solution of twice the strength mentioned above, and with the gelatined surface upward, so as not to touch the solution at all, the film being allowed to receive the bichromate by absorption. In this way the most soluble tissue may be sensitised without injury to its surface, although the difficulty of drying will, of course, still remain. It need scarcely be observed that the sensitising process must be conducted in a darkened room, and as the bichromated gelatine is very much more sensitive than albumenised paper, greater precaution must be taken to exclude all light during this process, as well as during the drying; in fact, the more nearly the tissue is treated as a sensitive collodionised plate, the more perfect will be the resulting print. When the tissue is perfectly dry it will be ready for exposure to light under the negative.

Before placing the tissue upon the negative, however, a border of opaque paper should be pasted round its edges, in order to secure the margin of the print from the action of light. This is necessary in order to secure a margin of unaffected gelatine, which may serve to secure the film to the plate during the development, or rather the removal of the unaltered gelatine. This precaution is absolutely necessary, or the film will break up during the process. The sensitised tissue must, therefore, be cut of sufficient size to allow of this unaltered margin being left, or the development cannot be conducted in safety. The exposure of the tissue to light may be made in the usual manner, but of course the progress of the print cannot be watched as in silver-printing, as there is no apparent change in the film. It may, therefore, be supposed that the production of prints by this process is merely guess-work in this particular. Such, however, is not the case, as the action of light and the consequent progress of the printing may be most accurately determined by means of the actinometer. There are several forms of this instrument, any of which may be used, but that invented by Mr. Johnson seems to possess in a high degree the advantages of simplicity and certainty. This little instrument consists of a tin box, with a small slit in the lid about an inch in length and one-fourth of that in width. The lid of this box is painted the same colour as that assumed by albumenised paper upon exposure to light. Inside this box is arranged a slip of Carrier's sensitised albumen paper. By means of a simple mechanism a portion of the paper is brought under this aperture, and when exposed to light it of course quickly darkens to the colour of the painted lid. The method of applying this to carbon-printing is extremely simple. Thus, supposing we have a very thin negative to print, the sensitive tissue being placed upon it in the pressure-frame, the whole is exposed to light in the usual manner. At the same time a portion of the sensitive paper in the actinometer is brought under the aperture in the box, and exposed side by side with the print. As soon as the paper has assumed the chocolate colour, matching with the top of the box, the print is removed from the frame; and if, upon development, the exposure is found to have been correctly timed, the negative is marked with a figure 1. Should it, however, require longer or shorter exposure, this fact is indicated by a figure in the margin. Thus, if two or three tints of the paper be required, the negative is marked with the number of changes in the actinometer, and printed accordingly. By the adoption of this method prints may be made with absolute certainty of correct exposure, provided the correct time necessary has been marked in the first instance. In this particular the carbon process is superior to the ordinary method of silver-printing, as no allowance has to be made for the somewhat irregular reduction which occurs in the fixing and toning baths usually employed.

The exposure to light having been carried out as above described, the next operation will be that of attaching the film to some suitable temporary support during the development of the image; which latter process, as we have before explained, consists of removing the unaltered gelatine and pigment. For this purpose a sheet of white ground opal glass will answer, or still better, one of the porcelain "slates" in common use. Mr. Johnson uses finely-ground plates of zinc; and, in fact, any material having a white substance, that is insoluble in water, and has a slightly roughened surface which may serve to facilitate the adhesion of the film, will answer perfectly. Before attaching the film to either of these surfaces, they should be cleaned, and rubbed over with a dilute solution of wax and resin in turpentine, the merest trace being allowed to remain. If this precaution be neglected, the film will probably adhere so closely to the plate as to defy removal, except by the destruction of the print. The plates being thus prepared, the prints should be immersed in cold water. Very shortly the curling inwards, caused by the expansion of the paper, will be succeeded by a tendency to curl outwards. At this period the print should be removed from the water, and placed gelatine-side downward upon the supporting plate, which has first also been wetted. The superfluous water should then be removed by scraping the paper down upon a plate with a scraper or "squeezer," made by securing a slip of india-rubber between two slips of wood. A little time may now be allowed in order that the print may absorb moisture, when it will be found that the proof adheres tightly to the glass or metal plate. No injury is effected by some little delay in developing the prints after they have reached this stage (say three or four hours), but they should not be allowed to become dry.

The plate with the print attached may now be immersed in water, raised to the temperature of about 100 degrees, or as warm as the hands can comfortably bear. In a few minutes the coloured gelatine will begin to ooze out at the edges of the paper, which will also show signs of detaching itself from the plate. In effecting this detachment, on no account must any force be used, as that would injure the impression. Hot water may be applied a second time if required, but this is seldom necessary; a little patience will usually be rewarded by success. After the removal of the paper, the plate holding the film should be freely rinsed with warm water, when the picture will gradually emerge from the sludgy mass of unaltered gelatine and pigment. This washing should be continued until the water flows clearly off the print, showing that the whole of the unaltered and consequently soluble gelatine has been removed. There is room for the display of some skill and tact in effecting this process of development, as a print which shows any signs of under-exposure may be often saved by removing it from the hot water and plunging it into cold water for a few minutes; afterwards continuing carefully the action with water which is only slightly warmed. On the other hand, an over-exposed print may be reduced slightly by continuing the action by means of very hot water; and the operator will find that this simple process of development is easily modified, as may be required by the condition of the print.

Should the exposure have been correctly timed, and the development properly effected, the plate with the picture upon it should be allowed to become dry before proceeding to transfer it to paper. For this purpose a properly prepared paper is required, which is supplied by the Autotype Company. The transfer process is easy if the proper paper is used, and due precautions employed in its use. One side of the transfer paper is coated with a substance which secures the perfect adhesion of the film, and which becomes soft after soaking in boiling water. The sheets should, therefore, be cut to the requisite size, and immersed in boiling water in a flat dish, until the coated surface becomes soft and pulpy. Having arrived at this condition, it may be laid wet upon the film, and smoothed down with the scraper as directed before. When the paper is thoroughly dry (and on no account before), the removal from the plate may be attempted. If started at the corners, the film will usually strip off easily, in some cases spontaneously; when, of course, the operation is complete, and the print may be mounted in the usual manner.

It frequently happens that carbon-prints present a dull surface, which is offensive to those who have been used to the high gloss of albumenised paper. In this case the defect may be remedied by applying to the surface of the finished and mounted print an encaustic paste, made by dissolving white wax in benzole to the required consistence. This paste should be applied by means of a soft linen rag, and afterwards the surface may be polished with a soft silk handkerchief. In conclusion, we may remark that, although in description this printing process may seem complicated and tedious, it is not found so in practice; and that the undoubted permanence of the proofs would well compensate for extra labour, even if this were involved, which it is not.

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SILK CULTURE.—VI.

By Alexander Wallace, M.D.

CULTURE OF THE BOMBYX YAMA-MAÏ IN JAPAN.

Inasmuch as the culture of the *Bombyx Yama-Maï* in Europe is still somewhat of an experiment, notwithstanding the partial success which has attended the efforts of the Baron de Bretton and others in Europe, and as it is pursued in Japan on a definite method, it will be desirable to reproduce here the best existing evidence on this point taken from the Third Report, by Mr. Adams (of her Majesty's Legation in Japan), on Silk Culture in Japan, being an account of a tour made by him in those districts where the culture of the *Yama-Maï* is systematically carried on:—

"From Shimonita we proceeded over the Wami Pass to Owaké, in Shinshiu, and thence by the Nakasendô over the Wada Pass to Lake Suwa, from there by Shiwojiri to Matsumoto, our object being to gather information respecting the *Bombyx Yama-Maï*, or oak silkworm, which is reared in the open air not far from the latter place.

"We arrived at Matsumoto on the 16th of June. It is a castle town of over 3,000 houses, lying on the eastern side of a broad level valley of high elevation and light soil. Immediately to its north a low range of hills runs partly across the valley, so that at first sight the town appears to be situated at the north-east corner of a plain eleven or twelve miles in length, and six or seven in breadth, surrounded by high hills. Further down, the valley re-opens, but is narrower; and above the hills, which on the western side rise abruptly from the plain, a snowy range of granite mountains is visible, dividing the province of Shinshiu from that of Hida.

"At Matsumoto we were informed that we should have to proceed twelve or fourteen miles further along the valley, in order to reach the centre of the most favoured district for the culture of the *Yama-Maï*. Accordingly, on the following morning we rode along rough roads and across swift torrents which are often impassable, till we reached the village of Furumaya on the opposite or western side of the valley. There we put up at the house of a head-man, Mokuzagemon, himself a rearer of the worm, and from him, as well as from Benjirô and Tozagemon, of the villages of Tateashi and Aragama, we gained much interesting information. Their accounts tallied entirely in substance. It appears that there are sixteen villages, the inhabitants of which form an association called the 'Matsukawa gume,' and are entirely engaged in the culture of the *Yama-Maï;* that this culture was first initiated about forty years ago, and since then had gradually taken greater dimensions, till the number of cocoons annually sold by the association alone is computed at not less than 20,000,000 The three men stated that the number which they severally reared each season averaged 170,000, 100,000, and 80,000, the price of each thousand being estimated at about four riyos (equivalent now to nearly four dollars); also that the cocoons, as well as the silk, used to be bought principally by merchants who came from Gifu, in the province of Mino. Now, customers also arrive from Echizen, Oshiu, Echigo, Yonezawa in Dewa, and from other places. The best sort of silk is sold, as we are informed, at about 840 riyos a picul; the inferior sort at about 530 riyos a picul. A stout kind of netting is manufactured from silk, and it is also made up with other raw material, such as cotton.

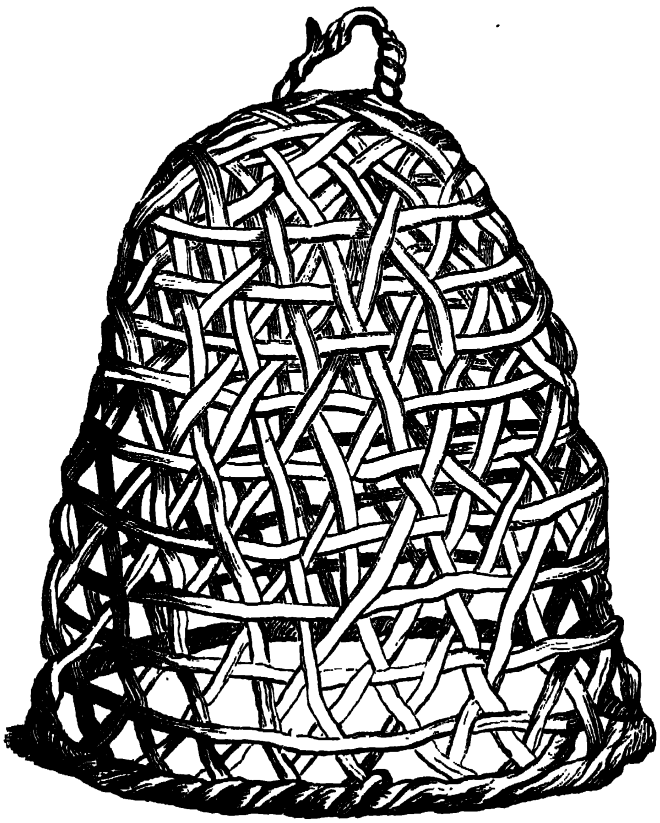


Fig. 8.—CAGE OF BAMBOO STRIPS ON WHICH THE EGGS OF THE BOMBYX YAMA-MAÏ ARE DEPOSITED.

"Close up to the western ranges of hills are a number of plantations of the 'Kunogi,' which is considered by the rearers of Furumaya and its neighbourhood to be the best food for the *Yama-Maï*. Its leaf is pronounced to be that of the *Quercus serrata*. The worms can be fed on other varieties of oak-leaves, but those of the 'Kunogi' alone are used for the purpose in this district. The plantation at Furumaya is less than a square mile in extent, and is thickly covered with plants of the species in question, some mere shoots of a year's growth, others varying from one or two to five or six feet, and others even taller. These plantations were said to extend at intervals for a distance of fifteen miles along the west side of the valley. The most approved method of propagating the 'Kunogi' was stated to be by sowing seed in a separate piece of ground, and then taking up the young plants and transferring them from these nurseries to the plantations. We were told that they are cut down close to the roots every three or five years, in order that fresh shoots might be given out. The soil is light and very sandy. The region is cold, and the leaves are often injured by the frost. The land belongs to peasants, who let it out in lots to different breeders, and there is a sort of rough surveillance, especially just at the period of spinning, but no particular watch seems to be kept, nor any thieving from to be apprehended. The real thieves appear to be sparrows and other birds, and though some scarecrows are put up, and guns are said to be let off at times, no serious attempt is made to put a stop to such ravages. The leaves, too, are infested with other caterpillars, and we were told that red ants, though not prevalent in this particular locality, did damage. Black ants, too, were noxious when numerous, but nothing was done to prevent them from going up into trees, where we saw them sometimes swarming about the *Yama-Maï* in great numbers. In fact, in this, as in every other matter, the general principle of letting things take their course, and of leaving the issue to Providence, was plainly and painfully manifest.

"The larvæ were mostly in the fourth and fifth stages, and it was a curious and most interesting sight to watch them clinging to the branches and leaf-stems, and to observe how completely their colour corresponded with the leaf on which they most delight to feed. Their bodies were of a pure and almost transparent with a bright line running down the sides, ending in a brown patch, the two quick-silver-like spots on each side being plainly visible. Diminutive blue spots were also to be seen at intervals along the body. So much did every colour and streak resemble the plants to which they clung, that it was some time before our eyes became sufficiently practised to distinguish them at all without close examination. The annexed sketches (Fig. 7) will give an idea of the larvæ upon the trees.

"The eggs of the *Yama-Maï* are deposited by the female on the bars of cages made of plaited bamboo strips, of the bell-like form delineated in Fig. 8. This is probably towards the end of July, and the cages are hung up one under the other, in rows of ten, under the eaves of the roof, where ventilation can be secured without exposure to sun, rain, or smoke.

"In the tenth month (November—December) it is generally the custom to take the eggs off the cages with the fingers, and place them in hempen trays of oblong form, with wooden rims about three inches high. Care must be observed that the eggs are not crowded one upon another. The trays are placed upon the verandah. A cold atmosphere is essential at this stage. Sometimes the eggs are not detached from the cages, and the latter are placed in a shed outside the houses, where good ventilation can be secured. The walls of the shed are formed of a coarse matting composed of reeds, and the roofs should be constructed of such material that no rain can penetrate inside and injure the eggs.

"About the end of the second Japanese month (say the beginning of April) the eggs are collected in small hempen bags, which are placed in boxes pierced with holes, in order to admit of proper ventilation. These boxes are either suspended out-of-doors amongst the trees, where no sun can reach them, or kept in a cold cellar, where they are put into deep holes dug in the ground. This operation is only necessary when the hatching has to be retarded, because the buds of the 'Kunogi' have not come out. The eggs, in short, have to wait for the buds, which are expected about the eighty-eighth day after the Japanese new year (say at the end of April or in the first ten days of May), though they may be much later. As soon, however, as the buds have come out, all the eggs, whether from outside or from the cellar, are brought into the house, and fixed with paste made of barley, or, still better, of buckwheat, on the middle of slips of paper five inches long and a quarter of an inch broad. About ten eggs are placed upon each paper, and all the slips are then taken to the plantation and tied to the branches of the 'Kunogi' in a single knot, which the nature of Japanese paper readily admits of, the two ends standing out at right angles to the branch. The paper thus surrounds a small section of the tree, the eggs lying on the external surface. The slips are placed in such a manner that the eggs may have a northern aspect, and not be exposed to the rays of the sun. One slip is sufficient for a small plant; two or three may be attached to a large one. In four or five days the hatching will commence, and it continues for five or six days more; the young caterpillars, on leaving the shells, immediately crawl from the papers upon the 'Kunogi,' and seek the leaves. We saw a number of these papers still remaining on the trees as they had been tied before the hatching, with the empty shells sticking to the surfaces, and we untied some and brought them away with us as specimens.

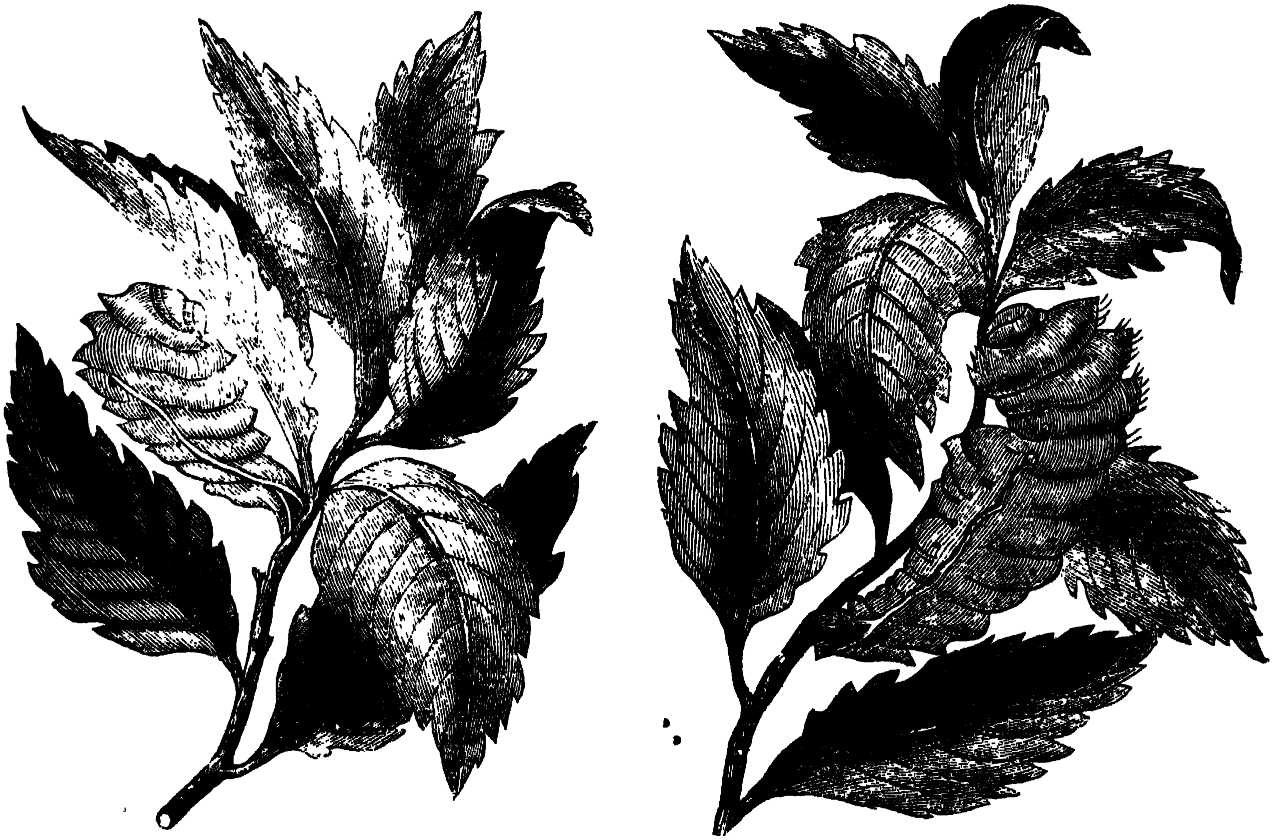


Fig. 7.—SKETCHES SHOWING THE SIMILARITY OF CATERPILLAR OF BOMBYX YAMA-MAÏ TO LEAVES ON WHICH IT FEEDS.

"The length of time between hatching and spinning, during the whole of which the larvæ remain in the open air, passing through four periods of rest, is reckoned at about sixty days, more or less, according to the temperature. We were told that the first rest commenced on the seventh day, and continued for two days; that the succeeding three periods of activity and torpor were severally longer than the first, and that the spinning commenced about ten or eleven days after the fourth rest.

"Three days after the commencement of spinning, said our informants, the hinder part of the cocoons is seen to be stained a white colour. This comes from the secretion of the *Yama-Maï*, which it emits after having finished spinning. The cocoons are then taken off the 'Kunogi,' together with the leaves to which they are attached, and a small portion of the branches. They are then brought into the house, and placed upon shelves. About ten days subsequently, the leaves are stripped off, and the cocoons, held by the lower and broader ends, are shaken. Those which do not rattle are considered to contain dead chrysalids, and after having been dried through the action of a charcoal brazier, are reeled. Those which rattle on being shaken are considered to be in good condition, and such of them as are to be reserved for seed are placed in trays, and moths emerge in about twenty-five days from the time of spinning. The remainder are of course subjected to heat, in order to kill the chrysalids, and are reserved for reeling.

"The moths emerge between four in the afternoon and night, and the great majority of the first moths are males. The proportion was stated to us to be 300 males to 10 females. The males are then secured in the bell-shaped cages already mentioned, and as the females emerge, they are distributed among the males. It would be best, we heard, to place but one couple in a cage: in practice, however, several couples were put into the same, otherwise there would not be sufficient cages. One of the men said he had as many as 500. The bottoms of the cages are then closed with paper. The coupling commences in the evening, and lasts ten or twelve hours, after which the males are thrown away and die. It happens now and then that other males, coming from a distance, fly to the bars of the cages and couple with the females inside; these, however, are looked upon, not as legitimate husbands, but as interlopers, and their presence or absence does not enter into the calculations of the rearers of this district. The females then lay their eggs, as already stated, on the bars of the cages. This operation lasts four or five days, the average number of eggs to each female being estimated at from 150 to 200. The females then die. The best eggs are those laid on the first two or three days, and it is considered preferable that the males which emerge on one evening should couple with the females which emerge on the following evening. The same process which has already been described is then adopted with the new eggs.

"With regard to other diseases, they stated that after the fourth rest dark spots sometimes came out upon the worms, which subsequently die before spinning; that they are also subject to attacks of diarrhœa, which prove fatal; that another disease shows itself by a watery fluid exuding from the pores, the worms turning a brown colour and then dying. No particular names appear to be given to these maladies. Our informants also said that if a considerable amount of rain falls whilst the egg papers are attached to the 'Kunogi' in the open air, the eggs are apt to be spoiled.

"We were shown a species of creeping plants called 'tonsuru,' with leaves resembling those of the convolvulus, and a dark stem, which sometimes cling to the 'Kunogi.' If the *Yama-Maï* eats of these leaves it is poisoned, and dies at once."

Sufficient evidence has now been given respecting this silkworm to show that there is a fair chance of success in suitable localities, and we are inclined to believe that the solution of two points will greatly help experimenters to the desired success. 1. It seems desirable that the culture of this worm should be tried on a large scale in a wood of some extent favourably situated; the worms might be fed in the open air, on the low-growing scrub, where the loftier trees could afford them shade without interfering with ventilation. A few streams running through the wood would be an advantage, and the aspect should be north rather than south. Lastly, not less than 10,000 eggs should be operated upon. 2. The *Quercus serrata* and other Japanese oaks differ very greatly in growth and appearance from our indigenous species. The Turkey oak (*Quercus cerris*) and the allied varieties most resemble the Japanese kinds, and certainly seem to be preferred by the worms. Large plantations of this oak I can remember at Burnham Beeches, near Slough, some twenty years ago: a locality, I should imagine, very favourable for an experiment. It might be worth while to keep this point in view. Another Japanese oak, which was sent to me in acorn, and on which the *Yama-Maï* is said to feed, has a very large leaf, much resembling that of the *Quercus ruber*.

It must be evident, from the information which has already been given on the culture of the silkworm, that it would be a very desirable acquisition to any country, and that could we, through its medium, turn the leaves of our oak coppices into silken fibre, it would be an enormous gain to this country. There are difficulties yet to be surmounted; but inasmuch as most Japanese plants and seeds flourish in Great Britain, I cannot but believe that with a little more information we shall be able to naturalise in the cooler and moister localities of Great Britain and Ireland this *Bombyx* and its valuable product, the strong raw silk that the moth produces.

FORTIFICATION.—XI.

BY AN OFFICER OF THE ROYAL ENGINEERS.

DEFENCE OF ISOLATED BUILDINGS AND POSITIONS.

It occasionally happens that in times of insurrection, and also in the ordinary operations of war, small bodies of troops are forced to shut themselves up in isolated buildings, and to continue their defence for some time. The short time that would probably be available under such circumstances must generally preclude the possibility of collecting sufficient supplies to enable the garrison to stand a siege, even if the buildings happen to be of sufficient strength to resist a continued and serious attack. Hence it cannot often happen that any very prolonged resistance would be possible, although in the Indian mutiny there certainly were several instances of its having been done; the most memorable examples, perhaps, of the defence of a single building being that of a house at Arrah, held by a few men against the Dinapore mutineers, and the defence of the Residency at Lucknow, which, with its neighbouring buildings and enclosure walls, formed a large isolated post, and withstood a siege of some months.

There is no doubt that if a building has been well chosen, and its defensive capabilities made the most of, a very formidable resistance may be made against greatly superior numbers, when the assailants are not assisted by artillery fire. This latter condition, however, rarely happens in the fighting between regular troops, and hence the great difficulty of determining what should be done in each case, the total destruction of the building and its defenders being a mere question of time, provided the possession of the post is of sufficient importance to the enemy to induce him to concentrate the fire of a large number of guns upon it.

In any well-built house, not only are the walls bullet-proof, but there are usually ample materials within it with which to barricade the doors and windows, so that, provided every part of it is thoroughly seen and flanked by some other, it will be almost impossible for the enemy to get sufficiently close to blow an opening in the walls by exploding bags of powder or discs of gun-paper (dynamite) against them. Most buildings are constructed with projecting porches, outhouses, walls, or balconies, which may be readily converted into flanking defences. It does not, however, often happen that these means exist for such a complete defence in every direction that it would be impossible for a small party of men to place powder-bags against some of the walls without being seen. Wherever such a deficiency exists it must be supplied by temporary constructions, or such an accumulation of obstacles must be made round the weak point that any close approach would be impossible, at all events without so much preliminary work as to arouse the garrison and draw on the working party the fire from numerous loopholes. It may at first sight appear a theoretical and fanciful idea to provide flank defence for such short lines as the gable ends of houses, etc.; but it must be remembered that if infantry, unassisted by artillery, are attacking other infantry who are in possession of a loopholed and fortified building, the weapons of the assailants are almost powerless against the defenders, whereas every shot fired deliberately and in almost perfect safety from behind a loophole should take effect outside. The advantage, therefore, lies entirely with the defence, and the only chance remaining for the attack will lie in being able, by a surprise of some sort, to send a few men forward to place bags of powder against the walls, the explosion of which will form an opening sufficiently large to enable the assaulting troops to rush in.

This operation of placing the powder is very simple, and to perform it only three or four men and a very short time are necessary; but being so few in number, and each man having certain definite work to do, it is essential that they should be able to perform their task without casualties, an event that would seem impossible if even one or two men are placed in a secure position for flanking the wall with revolvers or breech-loading rifles.

The two most ordinary modes of obtaining this flank defence are by "tambours" and "machicoulis galleries." The former are a species of kaponier, with or without a roof, formed of stockade work, and projecting sufficiently from the wall to flank it by the fire from several loopholes. As in all stockaded buildings, the labour necessary for their construction is considerable, and the liability to destruction by artillery fire is very great. They are, therefore, often impracticable, and cannot be adopted; although in cases where there are ample means and time available they may be of great use. The Prussians employed them frequently in their lines of investment for flanking long walls which were too extensive to be powerfully held without some such assistance, and which if unflanked would have afforded cover to the enemy without materially checking his advance. The long wall forming the enclosure of the "Haras," near Garches, in the lines round Paris, was defended in this way.

The defence by machicolated galleries is a very old one, and may be seen in most old castles or fortified buildings of the Middle Ages, where approach to the foot of the wall is prevented by the fire from loopholes in the floor and sides of small projecting balconies supported on corbels near the top of the building. The modern machicoulis is a wooden balcony with bullet-proof front and sides, supported on beams which project through holes in the outer walls sufficiently far to allow of a vertical defence by means of pistols and short rifles. It is troublesome to construct, and so easily destroyed by artillery, that if the close approach of the enemy can be prevented by any other arrangement, it will often not be worth while to employ it as a means of defence. A bullet-proof screen or shutter placed in an inclined position, like a sun-shade, at a window or other opening, may with less labour be arranged so as to hide the defenders from view, and at the same time admit of a vertical defence for the wall.

In the choice of a building for defensive purposes, next to the important question of flank defence, its liability to be set on fire, and the means by which this difficulty may be met, should be carefully considered. There must be an ample water supply, thatched roofs and inflammable out-buildings must be removed, and all hay-ricks or stacks of firewood near to it must be burnt or destroyed, as a conflagration on the windward side of a house at the moment of attack would vastly increase the difficulties of the defenders, even if it did not result in setting fire to the building itself. There should be a clear space for some distance round the house, affording no cover for the enemy's marksmen, and its position should be such that, while it commands the roads by which the enemy will probably advance, it is not itself commanded by the roofs and windows of other more lofty buildings within range. As regards the work to be done inside the building: in the first instance carefully barricade and loophole the basement and ground floor, constructing and accumulating as many obstacles as possible round the outside. Care, however, must be taken that in the endeavour to obtain a powerful fire the lower walls are not so weakened by breaking numerous loopholes through them that the general stability of the building is affected; for it must be remembered that under the fire of artillery portions of the walls will be carried away, and that the weight of the roof, floors, etc., eventually may have to be borne by only a portion of their original supports.

It is generally considered that the garrison of the lower storey should be more numerous than that of the upper; and doubtless if without danger to the building sufficient numbers of loopholes can be made to employ the available number of men, there is an advantage in so doing, as the fire at that level will probably be more destructive than the plunging fire from above. As a rough guide to the number of men wanted, exclusive of the reserve, it is generally assumed that one man for every six feet of wall-space upstairs will suffice, and that the men are somewhat closer packed below; a considerable reserve being always kept in hand to replace casualties and perform various duties, such as cooking, etc. No rule of this kind can, however, be of much real value, as so much must depend on the shape and size of the building and the circumstances and object of the defence.

Loopholes at the angles of a building have a greater range, and enable fire to be directed on the sectors of undefended space in front of the angles, but they are more difficult to form than the ordinary ones. The great increase of power that has resulted from the use of breech-loaders renders it less necessary than formerly to crowd the men closely together, and every effort should be made to ensure their being able to use their rifles with freedom and effect. In the flanking defences, where the men have only to fire in one fixed direction, and where it is very important to get as much fire as possible from a given length of flank, there seems no reason why they should not be placed as close together as when standing in the ranks, provided long horizontal loopholes can be made for them to fire through.

In walls three feet or less in thickness, the neck or narrow part of the loopholes should be on the outside, and not less than three inches wide. The bottom of the loophole or sill should be about 4 feet 3 inches from the floor or banquette, and when considerable depression is required this height must be reduced. Pickaxes, crowbars, and hammers are required for making loopholes; and in ordinary brick walls, from nine inches to two feet thick, a couple of men should make a loophole in from ten to twenty-five minutes. The increased penetration of modern rifles renders the task of rapidly providing bullet-proof protection for the doors and windows of a defensible building more and more difficult. Boxes filled with earth, and sandbags or pillow-cases filled with earth and carefully built up, will answer the purpose, if they can be obtained in sufficient quantities. Doors and window-shutters can be rendered partially bullet-proof by nailing several extra thicknesses of planking diagonally across them until the required height of cover is obtained. When it is remembered, however, that our new infantry weapon, the Martini-Henry rifle, is capable of penetrating three thicknesses of three-inch fir planking at fifty yards, it would appear almost hopeless to try to obtain security by this means. Logs of wood, rolls of carpet, chests of drawers filled with earth, etc., can all be made use of with more or less success, and if perfect protection cannot be obtained, cover from view will often be of much use. It is important that the enemy should not be able to see whether the loopholes are manned or not, and therefore by day there should not be too much light in the rooms, and at night the less number of lights in the building the better.

Much has been said by various writers on the advisability of preparing for a defence of a building from room to room, and for a retreat from the lower floor by means of ladders to the upper rooms, from the floors of which a fire can be maintained on the enemy below, who are unable to follow, owing to the removal of the ladders and ordinary staircases. Such obstinate defences as this have undoubtedly often occurred, and therefore it would be presumptuous to say that under certain circumstances it may not be advisable to adopt similar measures again. It does, however, seem clear that if the assailants, in spite of the fire from the building, can succeed in forcing an entrance, and if, in spite of the equality of the fighting when they can only enter two or three abreast, they are able to drive the defenders to take refuge upstairs, it will not be long before they are able either to explode bags of powder in the lower rooms or to set fire to the house, which would probably at once put an end to the defence. It would, therefore, appear more advantageous to devote every effort to render the approach to the outside of the house difficult, rather than to elaborate a system of internal defence, which may possibly never be required. The foregoing remarks have been made chiefly with reference to a single building, but they will also apply generally to any group of buildings which has to be defended by infantry as an isolated post. Of course, where the buildings are not already connected by walls, out-houses, etc., the enclosure must at once be completed by means of stockades, abattis, etc., and where this has been done the same general arrangements as have been described would be adopted.

Isolated groups of buildings or villages may have to be defended under such very different circumstances that it will be impossible to do more than notice a few of the most ordinary cases. They may be occupied to assist the rear-guard of an army in covering its retreat, or the leading detachments of an attacking force may seize them, simply in order to enable them to hold their ground until the mass of their troops can be brought up. They may also have to be defended because they form important advanced posts in front of a large defensive position occupied during a general action. The defensive object in each of these cases being somewhat different, the nature of the practical work to be done in each case will also to a certain extent vary.

In the two former cases the object is obviously to gain time, and as the direction of the attack they are likely to receive is known, they need not necessarily be treated as closed works, but rather with reference to defence in certain directions only. In other respects, however, the conditions are dissimilar, for in the case of a rear-guard it may occasionally be necessary for the buildings to be obstinately defended to the last, even if by so doing the garrison is annihilated or taken prisoners, though of course the retreat of the defenders should as a rule be carefully provided for. This is essentially one of those cases where preparations for a successive defence from house to house, and from every advantageous point along the line of retreat, can and should be arranged. In retreating, the main body of the force will have passed through the village some time before the rear-guard arrives; consequently the officers in command have the opportunity of examining its capabilities for defence and designing their scheme, the necessary working parties and tools for carrying out which they probably have the means of supplying. This process should be repeated at convenient intervals along the line of retreat, and the rear-guard itself will be guided by orders received from the main body how long to continue its resistance at each point and when to retire.

The measures to be taken by an advanced guard occupying a village temporarily will differ from the foregoing inasmuch that the commander has probably no previous knowledge of the place, has probably a very short time in which to arrange his plans, and no resources as regards tools or materials besides those carried by his own men, as the inhabitants will most likely have fled. Here it is evident that every effort will in the first instance be made to strengthen the front and flanks of the village without barricading the streets, etc., in any very solid way, lest by so doing the subsequent advance of the main body should be delayed. With a rear-guard, on the contrary, as the roads and streets can only be of use to the enemy, any obstacles whatever that will delay his advance must be employed. The regularly-organised advanced guard of a large army would probably have a sufficient force of engineer officers, and men to do any requisite work but during a long general action the success at some one point may cause the enemy temporarily to retire from a village, in which case, if there are no engineers at hand, it should be at once seized and fortified by the nearest battalions of the attack, when great judgment will be required to turn the small amount of work possible to the greatest account. Any success of this kind should be promptly supported by numerous bodies of engineers from the reserve, carrying with them the tools and implements most likely to be of use; and if, owing to the fire, they are unable to work at strengthening the front line, they should be actively employed in retrenching the position and loopholing houses, which will enable the troops to remain in the village even after the outskirts have been re-captured by the enemy.

When the buildings to be defended are in front of a line of battle, there probably have been some few hours available for preparation, and an ample garrison can be left for their defence. The difficulty, however, is to devise any arrangement that will enable them to hold out for several hours under a concentrated artillery fire, and surrounded by the enemy's troops. Being nearest to his position, they will have to withstand the first brunt of the attack, and are sure, for a time at least, to be cut off by the wave of attacking troops as it rushes forward to assault the main position beyond. In these cases it is evident that they must be capable of resistance in all directions, and also that a means of communication on the side next the position should invariably be made, by which, when a favourable opportunity occurs, reinforcements of men and ammunition may be sent to their assistance. The celebrated farm buildings of Hougoumont and La Haye Sainte, that played so conspicuous a part in the battle of Waterloo, belong to this catagory; and in the late war in France there were numerous examples of buildings defended under similar circumstances—for instance, the farm-house of St. Hubert, about 1,000 yards in front of the French left centre at Gravelotte, and the farm of La Bergerie, near Mont Valerien, which was so stoutly defended by a company of Prussian infantry against the last great sortie from Paris, 19th of January, 1871.

The defence of the village of Le Bourget, and numbers of others round Paris and Metz, will be found most instructive examples for any one really wishing to study the subject. Want of reliable facts as to time, men employed, etc. etc., however, render it undesirable to attempt to describe what was done, until the official French and German accounts are published.

In some cases the buildings in a village or town are so grouped as to be rapidly capable of conversion into a strong fortified post; while in others these conditions are most unfavourable—as, for instance, where the houses form one long street, enfiladed from the enemy's position, and liable to attack on either flank. Under these latter circumstances, it is clear that the enemy's artillery will in a short time render the defence of the end houses of the street an impossibility, and that any attempt to hold them would be futile. It would seem best in such a case to hold, in the first instance, an advanced line of trenches traced so as to avoid enfilade as much as possible, and when obliged to leave these to retire to houses, which being further up the street, are not so likely to be ruined as the end ones. These houses must have been previously determined on, and loopholed, the barricades in the street being so placed as to be commanded by them. The houses so chosen should if possible be isolated from the others on the side next the enemy, or if this is not possible, the floors and partition-walls of the houses next to them should have been cut away, to prevent the enemy working from house to house after he has once gained the end of the street. If the barricades are manned, the assailants will avoid a direct advance up the streets, and will endeavour to command and turn them by fire from the roof and windows of the houses they first get possession of. If the defence has been carefully prepared, these houses should have been previously mined, so as to be blown up as soon as the enemy's troops appear to have occupied them in force. To avoid this, no buildings should if possible be occupied by large crowds of troops until they have been examined by the engineers, with a view of detecting the mines, and disconnecting the wires or powder hose with which the charges would be fired. As regards barricades, they should be made at places where they are flanked, and where, if possible, they are screened from direct artillery fire, and there should always be a means of retiring round them, through the houses right and left.

In the attack of a fortified village, the assailants will endeavour by a series of false attacks to deceive the defenders as to the point on which the real attack is to be made. The troops, however, making the feigned attack should be sufficiently numerous and well organised, that if they find a weak or unguarded point they can really assault the place. The artillery will be used as usual to enfilade the longest lines, dismount the guns, and destroy the flank defences and obstacles. The fire of the defenders will be kept down by the artillery and by the leading division of the attack, who advance in skirmishing order, closely followed by a large working party of engineers, to destroy the obstacles, and prepare an entrance for the stormers.

In order not to give the defenders time to assemble it is very necessary that the attacking troops should advance as rapidly as possible, but before entering the village it is of still greater importance that until the working parties have cleared the way there should be no confusion or mixture of the troops having separate duties to perform.

After once an entrance has been effected, all previous arrangements must be more or less upset; and the success of the attack will depend on the vigour with which it is pushed forward, and the numbers with which it is supported. While the storming party is forcing its way onward, a working party should be employed in fortifying any houses or buildings favourably situated for covering the retreat in case of a reverse. Subject, of course, to variations depending on the circumstances of each case, the following is the general organisation of an attacking column:—(1) Skirmishers; (2) engineer working party; (3) escalading party, carrying ladders, ropes, grapnels, etc.; (4) storming party of infantry, followed by supports and reserves. The intervals to be observed between these, as well as their numbers, will entirely depend on circumstances. The hour for those attacks is usually just before dawn, as this allows of the assembly of troops and first advance possibly being made unseen, and of the subsequent operations being facilitated by the increasing daylight.

TECHNICAL DRAWING.—LXVIII.

DRAWING FOR BRICKLAYERS.

The methods of breaking joint in short portions of walls built according to the common English bond having been thus illustrated, it now remains to treat of the system to be adopted in effecting the same object at the corners of buildings where two external walls meet at right angles.

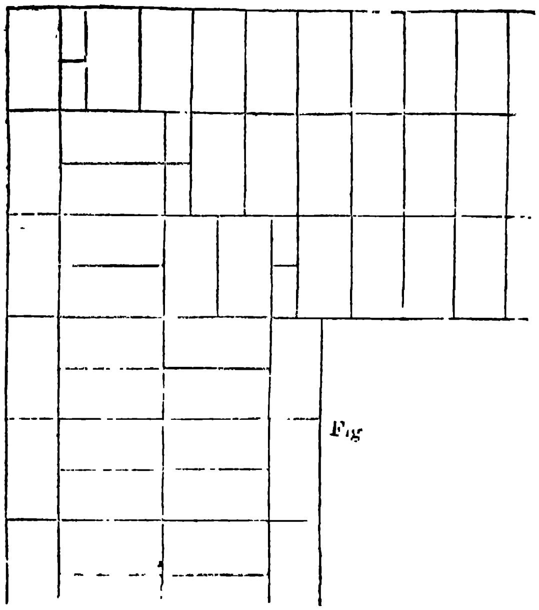
In this case it is proper, commencing as usual from the corner header, at the external angles to introduce a set of closers, covering an extent equal to the whole thickness of the particular wall of the two (that is, if the two walls be of unequal thickness, which may often occur in practice) to which that header belongs; while closers need not, however, be disposed in a continued straight line, but checkerwise, so as to approach towards the re-entering angle, but without actually reaching it, and thus none of them will be seen in the inside of the building. They must all be laid parallel to each other.

Figs. 559 and 560 represent this arrangement, showing two successive courses of the corner of a building formed by the meeting of two walls each supposed to be three bricks thick.

In this arrangement it will be observed that of the two walls which meet each other at the angle, one shows a stretching course, whilst the other shows a heading course on the same level, and *vice versâ;* and these two arrangements meet each other at those parts of the brickwork where the three closers, which are equal in all to the length of three bricks (the thickness of the wall), extend entirely across the wall.

In building English bond a variety may be introduced by using so many three-quarter bats instead of whole bricks as corner headers at the extremities of every heading course as will make up the thickness of the adjoining wall; and in this case no closers are required.

Figs. 561 and 562 represent the plan of the corner of a building in which the walls are three bricks thick, and where this arrangement has been followed. In each heading course six three-quarter bats are used near the angle, which extend over a space equal to three bricks—that is, the thickness of the wall. In this case it is evident that all the joints will be perfectly broken without the aid of closers. These three-quarter bats are visible in Fig. 562, in which it will be seen that the



Fig

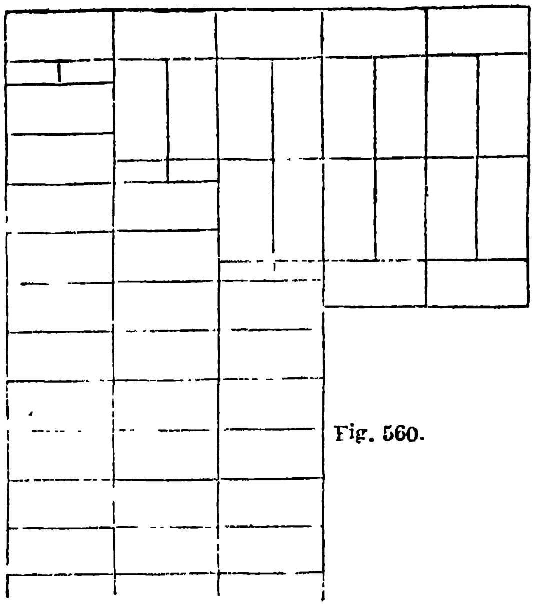


Fig. 560.

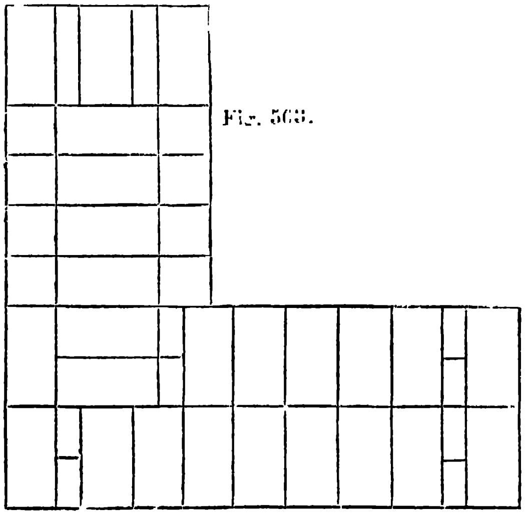


Fig. 563.

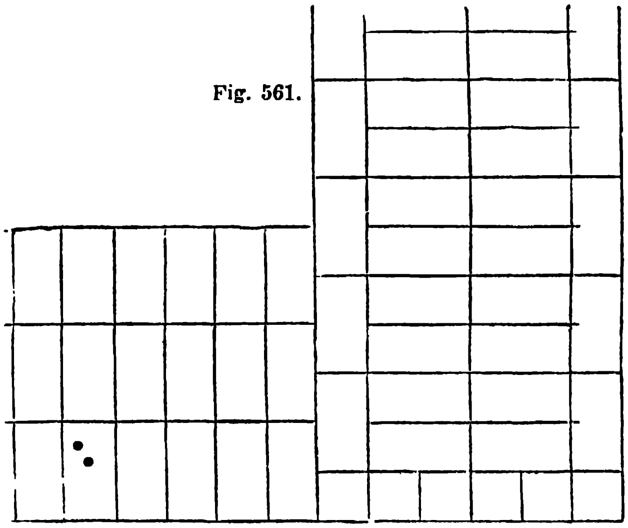


Fig. 561.

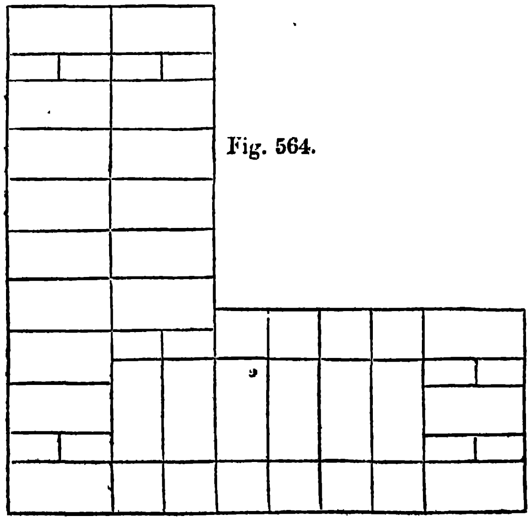


Fig. 564.

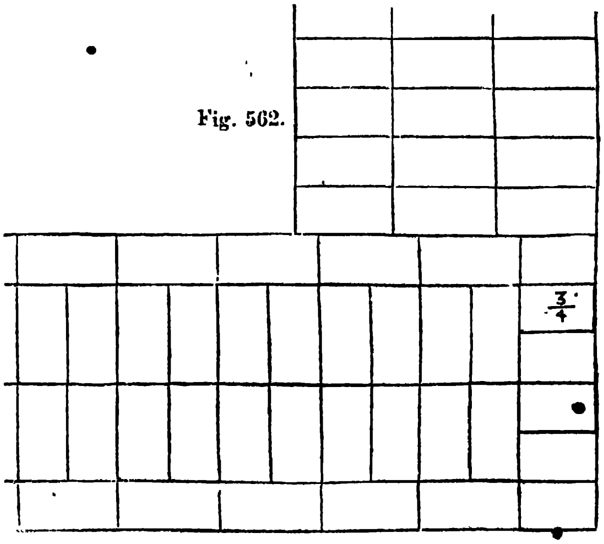


Fig. 562.

corner header of one wall shows as a short stretcher in the stretching course on the other side of the angle.

HEADING BOND.

A brick wall may be built all heading bond—that is, without using any stretchers at all, excepting in alternate courses at the corners of the building, as "quoins," as they are technically called, and at the various other angles or breaks occasioned by projections and recesses, or by the openings for doors and windows.

Figs. 563 and 564 represent the plans of two successive courses thus executed. One corner of the building is shown with the walls extending on each side as far as two openings, which may be supposed to be doors or windows.

Although from its neat appearance this style has been preferred by some architects, it is not generally considered so good as the common English bond, for as compared with that it merely consists in breaking every external stretcher into a couple of bats, as shown in Fig. 564, which certainly cannot be an advantage.

SEATS OF INDUSTRY.—XXVII.

LIVERPOOL.

BY WILLIAM WATT WEBSTER.

ALTHOUGH the manufactures of Liverpool are comparatively trivial, there is no town in the world that illustrates so clearly, and upon so extensive a scale, the indirect influence of manufacturing enterprise upon national prosperity. To its intimate connection with Manchester, Oldham, Bury, Bolton, Ashton, and other great manufacturing centres in the north of England, Liverpool owes, in a great measure, the proud position it occupies as the second town in the kingdom as regards population, and the first port in the British Empire, and consequently in the world, as regards the extent of its foreign trade. It is an integral and highly important part of the manufacturing system of England, and the story of its rise and progress, especially in later times, forms an interesting and instructive chapter in the history of British industry.

The etymology of the name Liverpool has given rise to much conjecture; but no satisfactory explanation of it has been given. In the earliest authentic records of the town that have been preserved, it is called Lyr-pul, and it has been suggested that the name is derived from the Gaelic word Lyr, "the sea," and that Lyr-pool means the "harbour of the Mersey." On the assumption that Leverpoole is the original orthography, the name has been associated with the family of Lever, which in ancient times flourished in the county, and also with the cormorant in the corporation seal, which is known in heraldry as a laver or liver. Previous to the Conquest, Liverpool was but a small and obscure fishing village; it is not mentioned in the Domesday Book. Ten years after William of Normandy landed in England, it is believed that a castle was built on a promontory between forty and fifty feet above the river, by Roger of Picton, on whom the Conquerer bestowed the whole district between the Ribble and the Mersey, and that the houses built round the base of this promontory formed the nucleus of Liverpool. There is a tradition that Henry I. conferred a charter of corporation on the town in 1129; but the charter of Henry II., dated 1173, is the first authentic record in its history. This document declares that "the estuary of the Mersey shall be for ever a port endowed with all the liberties belonging to a port of the sea, and that the men of Lyr-pol near to Toxteth may come and go from each side of the sea with their ships and merchandise, free and without obstruction," the sea here referred to being, of course, the Irish Sea. Henry II. also erected a number of what were called burgage-houses, whose tenants were the primitive freemen of Liverpool, and the Crown continued to draw the rental of these houses up to the time of Elizabeth. In 1207 King John granted a new charter, and in 1229 Henry III. made Liverpool a free borough with a merchant's guild and house, and conferred on its burgesses like liberties and privileges to those enjoyed by their brethren in London, Bristol, and other towns, no stranger being allowed to trade or settle there without the sanction of the municipal authorities. For two centuries this smallest of the chartered towns of England was so poor that it sent no representative to Parliament, and for five centuries it can hardly be said to have had a history. During the latter long period, the wardership of the castle was retained by members of the Molyneux family; and about the year 1360, a tower that had been erected in the previous century, as an outguard to ensure the safety of the castle, came into possession of the Stanley family, and this building was afterwards an occasional residence of the Earls of Derby. In the reign of Henry VI. the Stanleys and the Molyneux had a violent feud, which required the intervention of the Government; and about this period the knightly family of More, of Bank Hall, had a mansion in Liverpool and large possessions in the vicinity. In 1524 Leland describes the town in his "Itinerary" in the following terms:—"Lyrpole, *alias* Lyverpoole, a pavid towne, hath but a Chapel, Walton a iiii miles of, not far from the Se is paroche church, the King has a castelet there, and the earls of Darbe hath a stone house there. Irish marchaunts come much thither as to a good haven. At Lyrpole is small custume payed that causith marchauntes to resorte. Good marchandis at Lyrpole, and moch Yris yarn that Manchester men do buy there." Forty-one years later Stow states in his "Survey" that Liverpool consisted of seven streets, containing 138 houses, and that its population numbered only 690. There were then in the harbour twelve ships, with an aggregate burden of 223 tons, and a total crew of seventy-five men. In a petition to Queen Elizabeth, dated 1571, reference is made to the place as "Her Majesty's poor decayed town of Liverpoole;" but Camden, writing in 1586, gives a more cheering description of it, noting, among other things, that it is "the most convenient and most frequented passage to Ireland," and remarking that the town was "more celebrated for her beauty and populousness than for her antiquity." It would appear that the merchants of Liverpool had trading connection with the continent of Europe at this date, for it was Humphry Brooke, one of their number, who gave Queen Elizabeth's Ministers the first intimation they received of the sailing of the Spanish Armada; but its chief trade was at that time, and for a long period afterwards, with Ireland. Chester, however, continued to be the principal seat of commerce with Ireland till about the middle of the seventeenth century. The transfer of this trade from Chester to Liverpool began by merchants of the former town using the latter as their port, the Dee having gradually become unnavigable for the larger class of ships, and for many years Liverpool was considered a sort of sub-port of Chester. In 1602, the inhabitants of the latter town asserted that "the town of Liverpool was but a creek of the port of Chester," and for many years they claimed a sort of lordship over Liverpool. In 1626 a new charter was granted to Liverpool by Charles I., making it a city, James Strange, Lord Stanley being its first mayor; but up till 1647 the port was subject to Chester officers. After the Irish rebellion of 1641, a number of Irish Protestants settled in Liverpool. During the civil war the town acquired great political importance. In 1644 it was defended by Colonel More against the army of Prince Rupert for three weeks, but was taken by storm: the royalist cause, however, being shortly afterwards utterly ruined by the defeat at Marston Moor, Liverpool again came into possession of the Parliament. Cromwell favoured the place as the most convenient port of embarkation for Ireland, and during the great plague and fire of London in 1665 and 1666, many merchants from the metropolis took up their residence in Liverpool. In Blome's "Britannia," dated 1673, it is stated that amongst the inhabitants of Liverpool are "divers eminent merchants and tradesmen, whose trade and traffic, especially into the West Indies, makes it famous," and "the sugar bakers and great manufacturers of cotton in the adjacent parts" are mentioned. During the reign of Charles II. Liverpool made great progress, owing to the opening up of America to British enterprise, and its merchants early took an active part in the slave trade, sending out ships to Africa for negroes, conveying them to America, and bringing back sugar, tobacco, and other goods, in exchange for their live cargoes. It was from Liverpool that William III. set sail for Ireland in 1690, three days before the battle of the Boyne. Nine years later, when it was erected into a separate parish, Liverpool had a population of about 5,000.

Liverpool advanced rapidly during the eighteenth century, chiefly by means of the trade its merchants carried on in slaves and tobacco. The first slave ship fitted out on the Mersey was dispatched in 1708; but by the year 1752, 101 Liverpool merchants were engaged in this infamous though lucrative traffic. Between the years 1700 and 1709 inclusive, the average annual importation of tobacco into Britain amounted to 12,880 tons, and Liverpool had a larger share of this trade than any other port in the kingdom, half the shipping and more than half the wealth of the town being embarked in it. To afford facilities for this trade, a wet dock was constructed in 1709, which was not only the first in Liverpool, but the first in the kingdom. By the year 1760 there were seventy-four vessels belonging to Liverpool, with an aggregate burden of 8,178 tons, engaged in the slave trade, and it continued to increase during the *forty-seven years* that elapsed before England ceased, in 1807, to participate in this iniquity. During the ten years from 1795 to 1804, when the slave trade reached its culminating point, it is calculated that the merchants of Liverpool shipped no fewer than 323,770 slaves from Africa to America and the West Indies. That this traffic was highly profitable to them, may be inferred from the fact that at the time it was being carried on, the greater part of the West Indies belonged to Liverpool merchants. The outbreak of the French war in 1756 put a stop for a short period to the slave trade, and the slavers of Liverpool were turned into privateers. At first they gained some slight success, but before the close of the war Liverpool suffered severely by way of retaliation, it having been blockaded by French privateers for seven weeks in 1758. In the course of the eighteenth century, the natural advantages of Liverpool for the prosecution of commerce were greatly enhanced by the construction of an immense system of canals. The first effort to improve the natural facilities for inland trade was the building of the Irwell and Mersey navigation (for which an act was obtained in 1720), by means of which raw cotton and cotton goods were conveyed to and from Manchester; and shortly after the completion of this work, the Weaver navigation was undertaken, which afforded an easy means of bringing the salt of Nantwich and other places in Cheshire to Liverpool, which speedily became an important article of export, and employed a large amount of shipping. These works were followed by the Sankey Brook navigation, completed in 1768; the Bridgewater canal, opened in 1773; the Trent and Mersey, or Grand Trunk canals; and the Leeds and Liverpool canal, which were finished in rapid succession; so that by the year 1816, Liverpool possessed a complete system of water communication, direct or indirect, not only with the great manufacturing towns of Lancashire, Cheshire, and Yorkshire, but also with the south coast, and, in fact, with nearly every part of England. Those canals have realised large profits to their shareholders, and they still bring in considerable revenues, notwithstanding the competition of the railways. It is worth mentioning that between the years 1777 and 1782, there were launched on the Mersey some fifteen war-vessels, of considerable tonnage, and carrying from sixteen to fifty guns, constructed to the order of the Government. As a matter of course, the population of the town kept pace with the growth of its trade. Between 1710 and 1760, the number of its inhabitants increased from 8,160 to 25,780, and the shipping belonging to the port increased from 84 vessels in the former of these years to 1,245 in the latter. By 1781 Liverpool had a population of 35,000, and possessed 2,300 ships; and by 1791 its population had augmented to 50,000, and its shipping to 4,200 vessels. In 1801 the population was 77,700, and the commercial fleet numbered 5,100 vessels.

But the most important factor in the prosperity of Liverpool has yet to be noticed, for it has been still more indebted to cotton than to slaves and tobacco put together. The beginnings of the cotton trade of Liverpool were exceedingly small. In a local newspaper, dated 3rd of November, 1758, the following advertisement appeared:—"To be sold by auction at Forbes and Campbell's sale-room, near the Exchange, this day, at one o'clock, twenty-five bags of Jamaica cotton in five lots;" and from that time cotton was regularly brought to Liverpool from the West Indies, although for a long time in exceedingly small quantities. In 1770 the imports into Liverpool included 6,030 bales of cotton from "the West Indies and from foreign countries, with the addition of three bales from New York, three bags from Georgia, four from Virginia and Maryland, and three barrels from North Carolina." Twenty-one years later only 64 bales of cotton came to Liverpool from America, but the total quantity imported from Portugal and the West Indies in 1791 amounted to 68,404 bales. In 1794, however, the supply from America had risen to 4,668 bales, and from that date American cotton came into the port in steadily increasing quantities till it largely exceeded the imports from the East, and became the staple article of the commerce of Liverpool.

It was not till Hargreaves, Arkwright, and the other inventors and improvers of cotton manufacturing machinery had created and developed the cotton manufactures of the north of England, that the cotton trade of Liverpool attained gigantic dimensions. In the year 1824, the quantity of cotton imported into Liverpool was 578,823 bales, and of this total 413,724 bales came from the United States of America. The total imports of cotton into England in 1830, from all quarters, amounted to 793,695 bales, and of this quantity no less than 703,200 bales came to Liverpool. Ten years later, 1,164,269 bales of cotton were brought to Liverpool, and in 1851 the quantity had increased to 1,748,946. It may be stated here that the quantity of foreign and colonial produce imported into Liverpool in 1858 was 1,384,353 tons, against 1,374,937 tons into London, and that the foreign exports from the former port amounted in the same year to nearly £35,000,000, or considerably more than one-half of the total value of the exports of the three kingdoms for that year, and more than twice that of London. The number of vessels that entered the port of Liverpool in 1851 was 21,071, representing an aggregate of 3,737,636 tons burden, and the dock dues amounted to £269,020, and the customs receipts to £3,510,033.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXIX.—RICHARD REYNOLDS.

BY JAMES GRANT.

This celebrated iron-smelter, and ultimately the inventor of the *iron rail* which is now used on all railway lines, was born at Bristol in the year 1735. Though educated in the peaceful persuasion of the Society of Friends, to which his parents belonged, when but a lad he felt a strong desire to become a soldier, and would have enlisted but for the dismay such a step must have occasioned his friends. Ere long this fancy or enthusiasm died out, and assuming "the drab," he settled down into a quiet and industrious Quaker.

After serving an apprenticeship to the iron trade in Bristol, he went to Coalbrookdale on business; while there he became acquainted with the Darby family, who had long been iron and brass founders in that district, so rich in mineral treasures. The Darbys were also "Friends," and received young Reynolds hospitably, and eventually he married Hannah, daughter of Abraham Darby, known as "the second," three of that name—father, son, and grandson—having been smelters and malt-mill makers in succession at Coalbrookdale since the first year of the last century.

Richard, through this connection, undertook the management of the iron and coal works at Ketley and Horshay. At the latter place he resided six years, and on the death of his father-in-law, in 1763, he removed to Coalbrookdale, and took charge of the more extensive iron-works there. By the wealth and enterprising spirit of the Darbys, these had become greatly enlarged, and found remunerative employment for a rapidly-increasing population. The firm did not confine their operations to the Dale, says Mr. Smiles, but extended their works far beyond its boundaries, and built foundries in London, Bristol, and Liverpool, with agencies at Newcastle and Truro for the disposal of the steam-engines and other iron machinery then in use for clearing deep mines of water, and many of the pumping-engines made on Newcomen's design were constructed at the works of the Darbys.

"Civilisation is economy of power," according to Baron Liebig, "and English power is *coal!*"

The increasing demand for iron gave an impetus to coal-mining; the works increased in magnitude and number, till the whole of that part of the glen through which the Severn flows, between two hills, presented a *tout ensemble* which, with the forges, engines, furnaces, and machinery of iron, constitute a spectacle of the most interesting and bustling description; and when the steam-engine had been perfected by James Watt, and enabled powerful blowing apparatus to be wrought by its agency, the production of pit-coal being rendered cheap and expeditious, inventions stimulated each other, and trade at Coalbrookdale enormously increased.

The rich coal and iron district there includes the Dale, and extends east to Lilleshall and Bridgnorth, north-west to Wellington, and thence by the wooded Wrekin, south-west to the road from Much Wenlock to Bridgnorth; on the west the boundary is broken by the Severn; but the area thus described consists of a platform raised 400 feet above the river at Madeley, and 500 feet above the sea. At all these points the coal-measures are fully developed, and next in importance to the beds of these are the layers of argillaceous carbonate of iron.

Up to the time when Richard Reynolds took charge of the works at Coalbrookdale, the conversion of crude or cast iron into malleable or bar iron had been effected entirely by means of charcoal. The process was carried on in a finery almost exactly like a smith's forge, "the iron being exposed to the blast of the bellows and in constant contact with the fuel. In the first process of fusing the ironstone, coal had been used for some time with increasing success; but the question arose, whether coal might not be used with effect in the second or refining stage. Two of the foremen, named Cranege, suggested to Mr. Reynolds that this might be performed in what is called a reverberatory furnace, in which the iron should *not* mix with the coal, but be heated solely by the flame."

Though doubting the success of the experiment, Reynolds encouraged the Craneges to attempt it in April, 1766, and the result of their invention surpassed the expectation of the three. The iron put into the furnace was old bushes, which are always made of the hardest metal, and the iron drawn forth was, according to Reynolds's own statement, "the toughest I ever saw. A bar, 1¼ inch square, when broke, appears to have very little cold short in it. I look upon it as one of the most important discoveries ever made, and take the liberty of recommending thee (Thomas Golding, of Bristol), and earnestly requesting thou wouldst take out a patent for it immediately."

His advice was followed, and a patent to the Brothers Cranege, as inventors of the process, was secured for them on the 17th of June, 1766; but other inventions superseded it, and thus it eventually was of no benefit to them.

Among the important improvements introduced by Reynolds at the Coalbrookdale Works was the invention and adoption by him for the first time of *iron rails*, in lieu of wooden tramways along those roads by which the metal and coal were conveyed to the furnaces and to the landing-places on the Severn. The first idea of constructing railways is supposed to have been entertained between 1620 and 1650, when they were roughly constructed of wood, and one of this kind existed at Preston Pans, in Scotland, for when the Highlanders routed the King's troops there, in 1745, the cannon of Sir John Cope were captured *on the railway*, or tram-road. Reynolds observed that the wooden rails soon decayed, were liable to be broken, thus interrupting business and incurring great expense for repairs; and to obviate these inconveniences, in 1767, he took up all the wooden rails and replaced them by plates of iron, thus fairly inaugurating the era of the iron railroad, and his example was followed on all the old tramways throughout the three kingdoms.

It was at his works that the *first* bridge of iron the world had ever seen was constructed in 1779, after long care and forethought, as an attempt had been made some twenty[*] years before to span the Rhone at Lyons, and proved a signal failure.

The erection of the bridge was perhaps due to the energy and enterprise of his wife's kinsman, young Abraham Darby, who having become proprietor of the Manor of Madeley, and finding that the owner of Broseley, on the opposite side of the Severn, was equally anxious to bridge the stream where it divided their possessions, and where its banks were steep, and the old ferry dangerous, set about procuring plans for the erection without delay. Empowered by Parliament, a company was formed; shares were taken by the adjacent owners, the Rev. Mr. Harris, Mr. Jennings, and Mr. John Wilkinson—the latter a man of great enterprise, and builder of the *first* iron ship. Abraham Darby was the principal subscriber; and Mr. Pritchard, of Shrewsbury, prepared a plan, which, according to Mr. Smiles, is still preserved. It proposed to introduce cast iron in the arch of the bridge, which was to be in span 120 feet, but only as a sort of key, occupying but a few feet at the crown of the arch; this very sparing use of cast-iron indicating the timidity of the architect in working with new material. Thus, had his plan been adopted, "the problem of the iron bridge would still have remained unsolved."

It was set aside, and another arch *entirely* of cast iron was prepared at the works under the superintendence of Mr. Darby and Thomas Gregory, foreman of the pattern-makers, and arrangements were made for carrying it into effect. The abutments were built in 1778, and the following year saw the bridge —with an arch 40 feet high, and 100 feet in span—opened for traffic. The model of this structure is still preserved by the Society of Arts. "If we consider that the manipulation of cast iron was then completely in its infancy," says Mr. Stephenson, in the *Encyclopædia Britannica*, "a bridge of such dimensions was doubtless a bold as well as an original undertaking, and the efficiency of the details is worthy of the boldness of the conception."

Its site across the Severn was judiciously chosen, and such is its utility that now a thriving town named Ironbridge has sprung up around it on that which was formerly waste land; "and it is probable this bridge will last for centuries to come," adds the author of "Lives of the Engineers:" "thus also was the use of iron as an important material in bridge-building fairly initiated at Coalbrookdale by Abraham Darby, as the use of iron rails was by Richard Reynolds. We need scarcely add that, since the invention and extensive adoption of railway locomotion, the employment of iron in various forms in railway and bridge-structure has rapidly increased, until iron has come to be regarded as the very sheet-anchor of the railway engineer."

When the Government, in 1784, proposed to levy a tax on pit-coal, Richard Reynolds urged upon Mr. Pitt, then Chancellor of the Exchequer, and upon George Lord Gower, afterwards second Marquis of Stafford, the extreme impolicy of such a barrier to progress.

In that year sixteen "fire-engines," as those of steam were then named, were at work in the Dale, eight blast-furnaces, and nine forges, in addition to air-furnaces and mills at the foundry; and these, with the levels, roads, and twenty miles of railway, gave work and food to a vast number of people. Reynolds did not wish it to be understood that he sought for any special protection for home-made iron, notwithstanding the low price at which it could be imported from Russia and from Dannemora in Sweden. "From its most imperfect state as pig-iron," he remarked to the Earl of Sheffield, "to its highest finish in the regulating springs of a watch, we have nothing to fear if the importation into each country should be permitted without duty." The nobleman he addressed on this occasion was that Earl of Sheffield who was President of the Board of Agriculture, and well known in the literary world as a writer on political economy; and the subsequent history of the iron trade has fully justified the anticipations of Reynolds.

When the latter became more advanced in years, he began to long for retirement; he had no desire to possess wealth, yet it had flowed upon him, and he resolved to relinquish his shares in the iron-works at Ketley to his sons, William and Joseph. The former, a man of science and an excellent mechanic, was the first to employ inclined planes, consisting of parallel railways, to connect and work canals of different levels; and Telford, the engineer, handsomely acknowledged the great assistance he received from him in planning the iron aqueduct by means of which the Llangollen branch of the Ellesmere Canal was carried across the Dee at the height of 126 feet above a deep ravine through which the river flows at the width of 2,600 feet. The necessary coilings were all made at the Ketley works.

In 1804 Richard Reynolds finally left the scene of his long labours in busy Coalbrookdale, and returned to his native town of Bristol. There he spent the close of his years in works of charity and benevolence; and though a rigid Quaker, he was fond of painting, poetry, and music. "Many were the instances of his princely, though at the time unknown, munificence. Unwilling to be recognised as the giver of large sums, he employed agents to dispense his anonymous benefactions. Thus he sent £20,000 to London to be distributed during the distress of 1795. He had four almoners constantly employed in Bristol finding out cases of distress, relieving them, and presenting their accounts to him weekly, with details of the cases relieved.

In the eighty-first year of his age, this good old man died at Bristol, on the 10th of September, 1816, and was followed to his grave by the poor of the city, while clergymen of all denominations joined in the remarkable procession. His obsequies were celebrated in the peculiar but unobtrusive manner adopted by the Society of Friends.

MAP AND PLAN DRAWING.—I.

By C. C. King.

DIFFERENCE BETWEEN MAPS AND PLANS—SHAPE OF THE EARTH—PROJECTION OF MAPS—TRIANGULATION.

Map or plan drawing is the delineation on paper of any part or parts of the earth's surface. The term *map*—derived from the Latin *mappa*, "a cloth," probably because maps were originally drawn for convenience' sake on this material—should be, strictly speaking, confined to a representation of an extensive tract of land, when it is called a terrestial or geographical map; but should the area consist chiefly of the sea or any other large space of water, its delineation is termed a hydrographical map or chart. When we simply endeavour to depict on paper any small area which would not, on account of its size, be materially influenced by the curvature of the earth, then we designate it a plan, that is, anything drawn upon a plane.

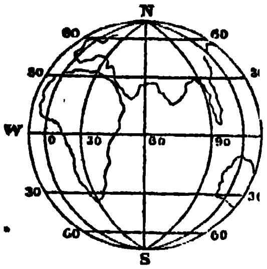


Fig. 1.

Maps and plans, therefore, as terms, are questions of degree, the former applying to large areas, the latter to smaller ones. Thus we speak of the *map* of England or Europe, the *chart* of the Atlantic Ocean or the Bristol Channel; but the *plan* of an estate, a village, or a house. A survey of a county is also a map; but as this under ordinary circumstances enters into very careful detail, and depicts with great accuracy, not merely the more important, but also the minor features of the district, it is entitled a topographical map, that is, one describing minutely all the natural and artificial peculiarities of the ground.

The object of all map-drawing is to exhibit the character of the country or countries, their boundaries, and the positions of their towns, villages, or great physical features, with such accuracy that they shall bear on our delineation both the same relative proportions and the same relative distances apart as they do on the actual globe. This is simple enough if the figure on which the copy is made is similar in form to that whence the copy is taken, the difference between the two being only one of scale. That is, it is easy to portray the surface of the earth on a similarly constructed sphere. But to lay down all the distances and details on the plane represented by our paper, so as to give them all their relative values, is a matter of considerable difficulty, and hence various methods have from time to time been devised to enable geographers to picture with accuracy the surface of the world.

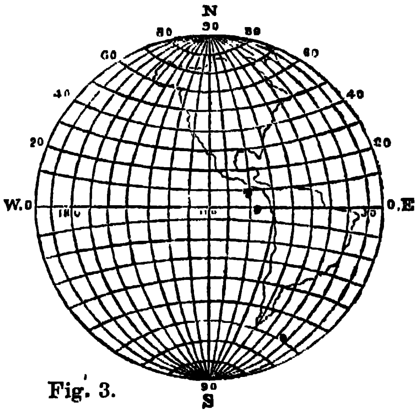


Fig. 3.

The shape of the earth is a sphere, or more properly speaking, an oblate spheroid; and for the convenience of geographical description its surface has been assumed to be intersected by a series of equidistant circles parallel to the equator, called *parallels of latitude*; and again by great circles passing through the poles, and dividing the equator into 360 equal parts, or geographical degrees. These are designated *meridians of longitude*. The geographical latitude and longitude, therefore, of a place are the co-ordinates which fix its true position upon the terrestrial sphere; and for the purpose of this determination the meridians of longitude are numbered from 1 to 180 east and west of that which is assumed to pass through Greenwich in English maps, and the parallels of latitude are enumerated north and south from the equator from zero to 90 at the poles. Other meridians and parallels for every intermediate minute and second of each division or degree are supposed to exist, though they are not drawn, and thus the position of any place on the earth's surface can be determined relatively on the map.

It must be remembered that in depicting any country or area, it is first necessary to construct, so to speak, a framework or scaffolding to which the relative positions of the physical or artificial features can be afterwards referred; and as this framework is represented in map-drawing by the meridional arcs and the parallels of latitude, the first aim of the draughtsman is to determine their position accurately on his paper. Having these carefully indicated, he can trace without difficulty the country he desires to portray; the exact position of any points he may afterwards select as centres, whence to extend the examination of the ground, being readily determined by the intersection of the meridians and parallels of latitude passing through them.

There are three methods of accomplishing this—(1) by projection; (2) by Mercator's projection; and (3) by the method of development. These various methods we shall now proceed to explain in detail, as fully as the space at our command will allow.

Projection is practically a means of representing in perspective the circles of latitude or longitude, and contains further three different plans for arriving at this result—viz., orthographic, gnomonic, and stereographic or central. They all labour, however, under the same disadvantage—clearly exemplified in the maps of the Eastern and Western Hemispheres found in the commencement of every atlas—that of distorting somewhat those parts of the area which lie towards the outer portions of the circumscribing circle. They are, therefore, rarely used, except in the cases above mentioned; and it will be sufficient merely to point out briefly the principles adopted in their construction.

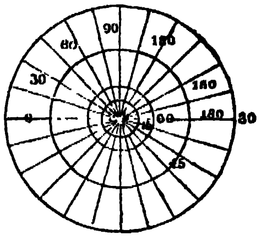


Fig. 2.

The orthographic projection assumes the eye of the observer to be at an infinite distance from the plane which, interposed between it and the sphere, is to receive the projected copy, and hence the visual rays to the various points are parallel to each other, and also perpendicular to the plane, which is technically called the "primitive." The result is to produce a representation of the world in which the meridional arcs are elliptical in form, having the meridian of Greenwich as the major axis, and the radius of the circle multiplied by the sine of the longitude as a minor axis; while the latitudinal arcs are shown by straight lines, the distances of which from the equatorial arc are determined by multiplying the radius of the circle by the sine of the latitude, and measuring them off on the first meridian north and south of the equator. This projection is usually made on the plane of the equator, or that of a meridian (Fig. 1).

The gnomonic or central delineation assumes the eye of the observer to be at the centre of the sphere, and is most commonly employed to depict the regions around the pole, when it is termed a "polar projection." In this case the meridional lines radiate at equal angles from the pole, and the parallels of latitude become concentric circles, whose distances from the pole are = radius × cot. latitude (Fig. 2).

The stereographical projection is used in most atlases to show the Eastern and Western Hemispheres, and it is supposed that the eye is situated on the surface of the sphere, which is considered to be a transparent solid, the plan being made on a plane at the opposite extremity of the diameter. All the arcs in this instance, except the central meridian and the equator, take the form of circles or portions of them (Fig. 3).

These systems are only applied in laying down a hemisphere or any large portion of the sphere, and are, therefore, not applicable to the circumstances under which maps are usually constructed. Reference to any atlas will show how much the shape of the continents is distorted, and this would naturally render these principles of projection of but little use where careful regard to relative proportion, especially in small details, was essential.

The first attempt to describe the earth's surface as a plane was made by Gerard Kauffman in 1512, and is called Mercator's projection, but the principles on which it is based were not fully explained till 1599, when Mr. Wright of Cambridge examined them and made an exposition of them in his "Correction of Certain Errors in Navigation."

" He depicted the surface as a true plane on which the meridional and latitudinal arcs were drawn as parallel straight lines respectively at right angles to one another. The former are equidistant, but by a mathematical rule the latter increase in distance as the latitude increases, in the same proportion as the lengths of the degrees of longitude on the respective parallels of latitude on the map are increased, owing to the fact that the meridional lines are represented as parallels instead of as arcs of great circles meeting at the poles. On the *sphere* the degrees of longitude measured on the parallels of latitude decrease in proceeding north or south; but on the *map* they are the same, on account of the parallelism of the meridians, so that it is necessary to make the distance between the lines representing the latitudes such that the same relative proportion between the length of a degree of latitude and one of longitude at any given point shall be the same on the map as on the sphere—in fact, that the bearing and distance of one place from another on both map and globe shall correspond (Fig. 4).

The method of development is the principle on which all ordinary maps are constructed, and it will therefore be desirable to examine it more carefully. There are many different plans of development, such as globular, cylindrical, and conical, but they are all similar in their principle—that of representing the earth on such a geometrical figure that it will not be altered by being unfolded or developed as a plane. A sphere cannot be thus developed without destroying it; but a cone or cylinder can be unfolded without altering the value of anything described upon its surface.

The conical method is most generally adopted, and it assumes the surface to be mapped to be a portion of a cone whose vertex is somewhere in the prolongation of the pole, and which either touches the sphere in a circle which is the middle parallel of latitude of the country to be delineated, or falling within the sphere at this circle passes without it at its extreme parallel. The surface of this portion of the cone when developed or unfolded forms the sector of a circle, and pictures with great accuracy the area to be examined (Fig. 5).

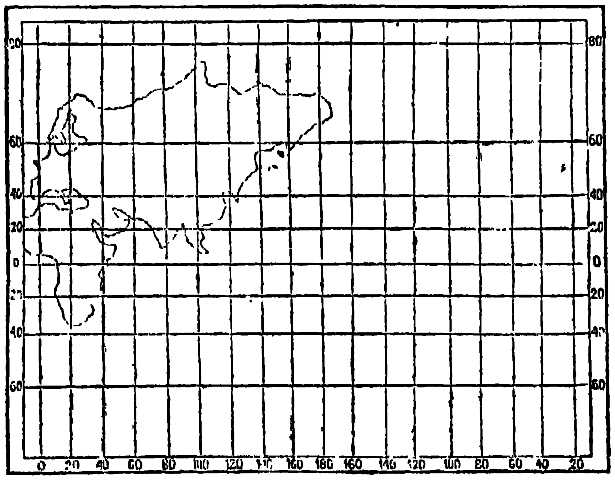
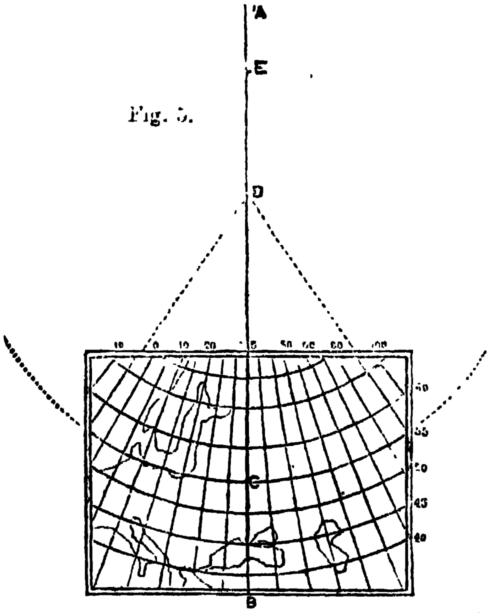


Fig. 4.

The method of describing it on paper is as follows:—

Draw any line A B for the central meridian of the map, and take the point C as a convenient position for the central parallel of latitude. Divide A B into any large number of equal parts, each of which is, on a chosen scale, to represent the degrees and minutes of latitude. Assuming the equator to be divided into 360 equal parts or degrees, this will give the radius of the terrestrial sphere as 57·3 of these, which measure from C to E. Take C D = the cotangent of the middle latitude of the plan reduced to a radius of 57·3 of the degrees of latitude already marked.* This point D will give the centre whence the arcs of latitude will be described through the points on A B. Divide the arc now described through the point C into equal parts, such that the length of a degree of longitude (the division required): the length of one of the degrees of latitude already described :: cosine of the middle latitude: the radius. Connect these points with the centre D, and the meridians for the given area are obtained.

Fig. 5.



We have now on paper a relatively correct representation of the meridians and parallels of latitude of the country we are going to map, and we can definitely fix the position of any point on it by its latitude and longitude, and thus obtain a starting-point for the further delineation of the ground. The principle on which all surveying is based—whether the more accurate representation undertaken by a state to show the boundaries of its territories, with its towns and villages, or the simpler topographical maps for military or statistical purposes—is that of uniting all the important points, physical or otherwise, on the area by a system of triangles commencing from a carefully measured base, which forms the side of the first triangle. These are further intersected by a network of smaller triangulations, which will fix all the secondary points on the surface, and finally the details of the ground are completed by measurement and the theodolite, or by sketching them with the aid of some other portable instrument. The degree of care with which this is done depends both on the scale to which the drawing is made, and the purpose for which it is intended. Thus, a military plan or map showing physical details on a large scale, made on actual service, is, though sufficient for the purpose for which it was designed, not essentially extremely accurate, though it may be made so if much time is provided for its construction.

It is evident that the value of this work of triangulation lies in the exactitude of the base-line, and the determination of the true position of the starting-point at one of its extremities. Extreme care in measurement, and a most painstaking repetition of observations are essential, for errors committed at this period of a survey are not merely continued but increased as the work proceeds. With such nicety has this determination of the base-line been conducted in the trigonometrical survey of England, that we find that a base measured on Hounslow Heath in 1791, was on re-measurement proved to coincide exactly in its mean length with the calculated dimensions assigned to it by a triangulation starting from a different base. A still more startling instance of the degree of accuracy which can be arrived at, is that of the measurement of a "base of verification" in Ireland, when, after carrying the triangulation across St. George's Channel, the distance between two points on either side of one of the Loughs was trigonometrically calculated. On measurement it was discovered to differ by only some two or three inches from this calculation.

The value of precision in the determination of a base-line is evidently most important, and whether in an extended survey or a rough sketch or reconnaissance, it should be fixed and measured with all the care that can be bestowed on it. Time is never lost by so doing.

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* This is readily done by means of the sector. Open the arms of the instrument until the distance between the points marked 45° on the *line of tangents* (described by T) is equal to the given radius C E. The distance between the points denoting the angles on the line of tangents whose *tangent* is to be found will give the required radius for describing the arcs of latitude. It may be mentioned that the cotangent of the middle latitude is = *tangent* of (90° − middle latitude), and that this tangent is the one employed in finding the radius from the sector.

The ground selected for it should be as extensive as possible, and should admit of a large series of prominent points and objects being seen from both ends of it. The more level it is, the more carefully can the base be measured, and the less necessity will there be for reducing it to an accurately horizontal plane. Having chosen an area that fulfils these requirements, one extremity of the base is accurately fixed by observations giving its exact latitude and longitude, and thus we have not merely a known point of departure on the terrestrial sphere, but are enabled to mark it definitely on the projected delineation of the surface we propose to transfer to paper.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S., ETC.

VIII.—NATIONAL MUSEUMS (*continued*).

1. *Site of the British National Museum of Natural History.*—Eight years after the date of that final estimate of space required, from the data herein contained, the Premier and the Chancellor of the Exchequer declared, on the annual report and estimates of the officers of the British Museum being brought before Parliament, May, 1870, that it was the intention of the Ministry to carry into effect, without any further delay, the erection of new buildings to contain the natural history collections, and so ease the other departments of the British Museum from their present engorged condition. It is understood that a plot of ground to the south of the present International Exhibition galleries has been reserved as the "Site for the Natural History Museum," such plot being so marked on the ground-plan in last year's catalogues of the International Exhibition. As this, according to an official plan of the Gore Estate published in the Report of 1862,[*] consists of 16¼ acres, giving a clear parallelogram of 1,100 feet long by over 550 feet wide, we may conclude that the question of site is at last definitely settled.[†] In the Report of 1860, it was stated that while land immediately adjoining the British Museum could not be obtained under £50,000 per acre, the Commissioners of Her Majesty's Commissions of the Great Exhibition of 1851 were willing to dispose of their land on the Gore Estate for such a purpose at £10,000 per acre. In consequence of the great delay, the value of the land, it is asserted, has been increased, by the interest that has accrued through the land standing vacant so many years since that offer was made by one Government department to another. The objection that was in former days raised against a site at South Kensington, as too uncentral a position for the convenience of a large portion of the inhabitants of London is removed by the completion of the outer circle of the Underground Metropolitan Railway system, so that it is really more easily accessible to those in the outskirts of the metropolis, than to those living in its centre, though the various means of access may be regarded as tolerably well equalised for all. In 1860, Mr. Panizzi stated that the average number of visitors to the exhibited collections at the British Museum was considerably over 2,000 a day, and it may be noted that the average attendance at the International Exhibition of 1871 was over 8,000 daily. What would have been the number finding their way to South Kensington daily, had that Exhibition, as in the case of the British Museum, been open to the public gratuitously? The South Kensington Museum has also been visited by vast numbers of people.

2. *Classes that National Collections have to provide for.*—*First* for consideration are the working scientific and artistic students, who would consult the various specimens collected and arranged for their use, in the same way as the literary students avail themselves of the books in our public libraries, under suitable regulations; *secondly*, technical students, who by examination of the specimens and attendance at lectures and demonstrations, wish to make themselves practically acquainted with the materials they employ in their trades or professions; and *thirdly*, the mass of the public, who merely visit such museums to pass the time, and find amusement. Of the lower order of visitors, Dr. Gray says that on the public days and holidays they stream quickly through the rooms without evincing any intelligent interest in what is set before them. Of this type I recently came across a very fair example in the mineralogical gallery of the British Museum. A boy was attracted by the brilliancy and brightness of colour of the sulphur group. "What's these, mother?" he inquired of a woman whose rotund body and equally rotund basket indicated materialistic rather than scientific tendencies. "Them's curosites, my dear," she replied; and this probably is an average conception of a large portion of the wage class who do their "outing" at our public museums. On the other hand, Dr. Gray also testifies to the intelligence of hundreds who come from the north, east, and south of London, especially from Spitalfields, with specimens of eggs and insects to compare and name. With this class the collection of British zoology is the most popular in the Museum. Professor Maskelyne speaks of the intelligent observations he has heard made by men of the working class on specimens arranged in his department. Mr. Robert Hunt and Professor Huxley testify to the intelligence and attention of the working men who attended the evening lectures at the School of Mines, and the latter observes in his evidence given before the Committee on Public Institutions,[*] "Even in difficult arguments they follow the whole case, and show the most perfect possession of the facts, by the questions they ask at the end of each lecture." This class, it should be noted, prefer consulting specimens displayed to the public, and rarely like to trouble the keepers with a request to consult the unexhibited collections in the private studies. A great number of teachers bring their pupils to see the collections. The experiment of opening the Museum late on Saturday afternoon did not prove successful, the number of visitors only averaging 500, instead of 2,000, on that day, but this may have arisen through it not being so generally known that Saturday had been made a public day, as on Mondays it has been densely crowded by the wages classes.

3. *Distribution of the Collections.*—To meet the requirements of the three classes herein specified, we find a generally recognised conviction that the working or scientific naturalists could best be accommodated in private studies, where every facility should be given for examining, and in suitable cases handling, the preserved skins, preparations, osteological specimens, herbariæ, minerals, etc. These studies should also form the store-rooms for all specimens least suited for public exhibition that can be packed away with great economy of space in the drawers and trays of cabinets, or in store-boxes, and should be in immediate communication with such portion of the public galleries as may be devoted to the same class of objects, also with the rooms set apart for the keepers of that class. In the studies should be stored what may be called *author's types* (in contradistinction to the term *typical forms* and *typical species*): these are the absolute specimens employed by an author when describing in book or periodical the natural history characters of an object. Thus the fishes in Yarrell's collection at the British Museum are the author's types, as connected with his standard work on "British Fishes;" such types, Dr. Gray observes, "are neither intended nor adapted for exhibition." In the studies should be kept, in preference to a central library, all books of reference, memoirs, papers in periodicals, etc., connected with the class of objects to which such rooms are devoted. At the British Museum "the books cannot be brought to the specimens nor the specimens to the books." A scientific library may be useful without specimens, but not a collection of natural history specimens without books. Both Dr. Gray and the late Sir William Hooker testify to the advantage of working over show specimens for determining natural history characters. Thus unstuffed skins, disarticulated skeletons, and dried plants, may then be placed in the student's hands with little fear of injury, and in that condition occupy a minimum of space. Dr. Gray states that a collection of birds

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[*] Parliamentary Papers, 1864, Vol. XXXII.

[†] During the present session (since this article was in type) Mr. Gladstone has stated that a vote of £30,000 was made last year for the erection of a Natural History Museum, and that the plans and designs had been approved, and tenders for the work invited.

[*] Parliamentary Papers, 1860, Vol. XVI.

equal to that in the Avian Gallery of the British Museum (300 feet by 50), occupying wall-space equal to 13,500 feet, may be stored in boxes in a room having no greater area than 900 feet; that the collection of insects is kept in cabinets in a room having an area of 1,509 feet, but if displayed in table cases would require a superficial area of 65,000 feet; that the Cumming collection of shells, the most complete in the world, only occupied two small rooms in a private house, but if displayed, would require a gallery "quite as large as that in which the birds and shells of the Museum are at present exhibited."

The class of technical students is only represented in this country by those who have attached themselves to the School of Mines, though we have a Museum of Economic Botany at Kew, and the germ of a Museum of Technical Zoology in the Food Collection at South Kensington Museum. But this class requires something more than a museum: it needs a teaching staff also, and a separate existence from a purely Scientific National Museum of Natural History. As there are professors of chemistry, physics, applied mechanics, mechanical drawing, mineralogy, mining, metallurgy, and zoology, with suitable illustrative specimens, models, etc., might not the sphere of this establishment be extended, so as to include instruction on botany, together with technical botany and zoology? If it has been determined to remove the existing teaching staff of the School of Mines to the new "Science Schools" at South Kensington, why might not this extension of its original sphere of action be made at a time so favourable for re-organisation? The mutual proximity of the scientific and economic collections is an obvious advantage. Whether the technical illustrations of the Kew Museum should be removed to London is a question that ought to be calmly discussed in the mutual interests of technical students and botanists generally. The Food Museum in the South Kensington Museum is on the spot to be utilised to the greatest advantage by the professors of the Science Schools, or of the Technological Museum, under whatever authority it may be placed.

The third class for which the directors of a National Museum have to provide—viz., the general public—is that which requires the greatest consideration, as to the best means of silently conveying information on the general structure of natural objects, their place in the scheme of Nature, and the "life-history" of living forms, in the most attractive manner. This series ranging from the mineral to man would, together with the specimens kept in store in the studies, embrace the entire *classified collection of natural forms*, mineral, vegetable, or animal; but beyond this, there should be an *introductory collection*, which should include specimens, models, diagrams, etc., to illustrate the terms used in defining the external and internal characters, parts, and forms of minerals, plants, and animals, and those epitomes of the characteristics of the great divisions of the mineral, vegetable, and animal kingdoms that are known as "type forms," such as are defined in Huxley's "Introduction to the Classification of Animals," and Rolleston's "Animal Forms," both but recently published. At the present time the specimens in the British Museum are jumbled, vertebrates and invertebrates in the same room, as birds and shells, mammals and corals, reptiles and crustacea. With ample space at command all naturalists advocate a progressive series extending from the simplest inorganic crystal up to the highest organised animal—man, but that only a selected series need be exhibited publicly, which it has been the fashion to term a "typical collection," but as Professor Owen very justly observes, "Those who are the loudest in advocating the restriction of exhibited specimens to 'types' have contributed least to lighten the difficulties of the practical curator in making the selection," and very pertinently raises the question as to what species should be selected as *the* "type" in various groups of the animal world he specifies. Others term what is aimed at as the "representative" system of arrangement. It is agreed that a national zoological collection should include the male, female, and young at one or more stages of maturity, the skeleton of the same, or parts thereof, winter and summer coats, plumage, eggs, nests, etc., of vertebrates, the metamorphic phases of invertebrates, every known variety of species obtainable (of vast importance in connection with Darwinian views), monstrosities, and distorted forms, etc.; but Professor Owen speaks of exhibiting only a portion of such treasures to public gaze, in which the curator must be guided "by the principle of selection." The fact is, the problem has never been worked out, as to what really is essential for public exhibition in a National Museum; but the change from Bloomsbury to South Kensington will give an opportunity for exercising the judgment of our practical curators, in determining what specimens, under what arrangement, would best represent in "Life-history Groups" our existing state of knowledge on natural history, and in such a manner as to make that other revelation of the Deity, "THE BOOK OF NATURE," written in stone tomes, on the leaves of plants and on the skins of animals, readable by the masses of the people.

TECHNICAL DRAWING.—LXIX.

DRAWING FOR BRICKLAYERS.

FLEMISH BOND.

FLEMISH bond implies brickwork so arranged that the bricks in every course present the appearance of a header and a stretcher alternately, from one end to the other, and in successive courses. Every header is placed over the centre of a stretcher below it. Closers are placed next to the corner headers in alternate courses in the manner and for the purpose already explained.

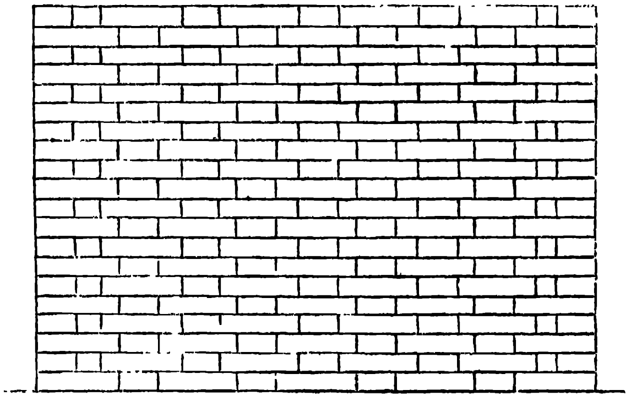


Fig. 565.

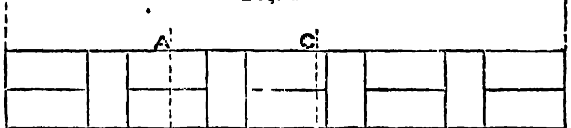


Fig. 566.

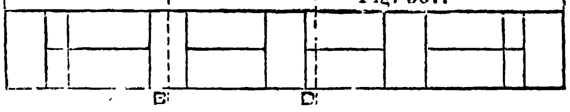


Fig. 567.

The appearance of a wall built in Flemish bond is therefore that shown in Fig. 565.

We again adopt as our illustration a portion of a wall equal

Fig. 570.

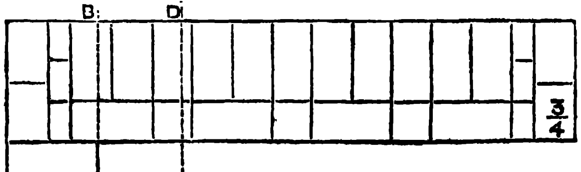
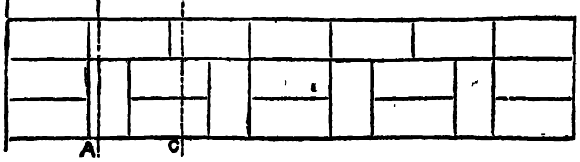


Fig. 571.



to seven bricks in length, one brick thick, and terminating with perpendicular ends. Figs. 566 and 567 are the plans of two successive courses of such a wall, and Figs. 568 and 569 are sections on the lines A B, C D.

It will be evident that in this wall both sides will be alike; but in walls of greater thickness two different arrangements may be adopted, called *single* and *double Flemish bond.*

SINGLE FLEMISH BOND.

In a wall built in what is called single Flemish bond, the bricks are so placed that whilst Flemish bond is seen on the one side, the bond on the other is English, which arrangement is only applicable to walls of more than one brick in thickness.

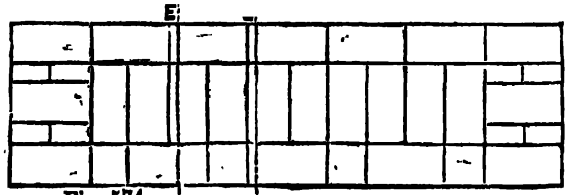


Fig. 574.

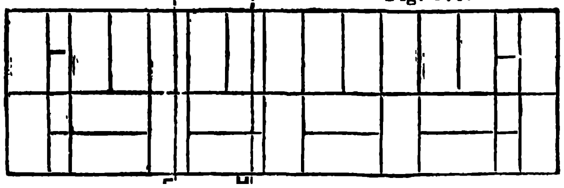


Fig. 575.

In such cases the Flemish bond, as being considered the most pleasing, appears, of course, on the face of the wall, or external surface of the building, which is eventually the only side generally exposed to view.

Common single Flemish bond is merely a modification of English bond, which may by some be considered more ornamental, but which is certainly not so strong.

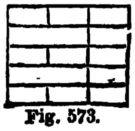


Fig. 573.

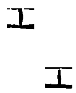


Fig. 572.

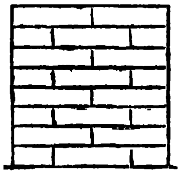


Fig. 576.

As in English bond, there are in this method heading and stretching courses alternately; the stretching course consists merely in using bats or half bricks, instead of whole bricks, in every alternate course in the face of the wall, as shown in Fig. 570. In the heading courses real headers or whole bricks are used in the face of the wall, between which every stretcher is backed with a second brick also laid as a stretcher (Fig. 571). With this exception of using double stretchers in the heading courses, the same arrangement is followed as in English bond of filling up all the remainder of a thick wall with headers. The rule of not breaking the horizontal joints is also observed in this method.

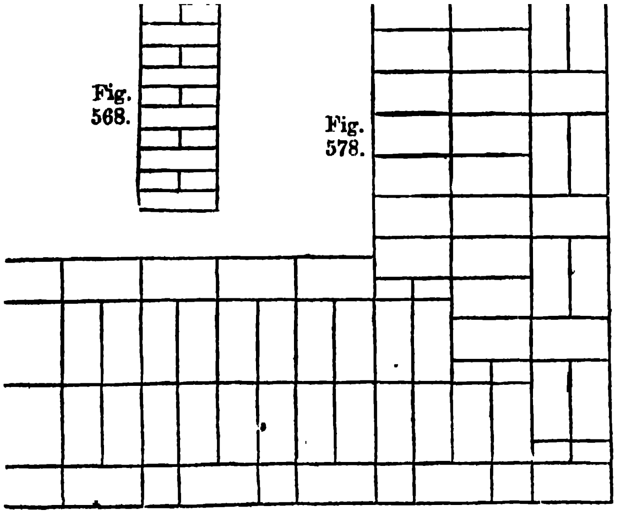


Fig. 568.

Fig. 578.

Fig. 572 is the section on A B, and Fig. 573 the section on C D of the wall of which Figs. 570 and 571 are the plans of alternate courses, the wall represented being of a brick and a half in thickness.

Figs. 574 and 575 are plans of two successive courses of a wall of the same description, but two bricks thick.

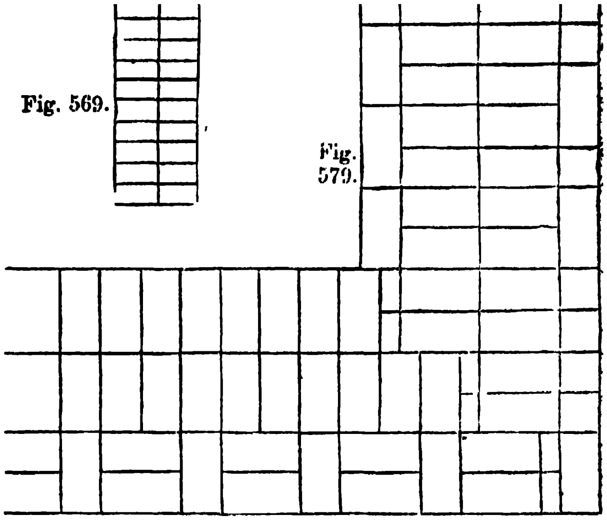


Fig. 569.

Fig. 579.

Fig. 576 is a section on E F, and Fig. 577 a section on G H.

Figs. 578 and 579 represent the plans of two successive courses of the corner of a house in which the walls are supposed to be three bricks thick, built according to the common single Flemish bond, and having the closers checkered in the usual manner.

SANITARY ENGINEERING.—XX.

MOULE'S PATENT EARTH-CLOSET SYSTEM.

In a series of preceding papers we have treated of in some detail the practical methods of dealing with sewerage where water is employed, and where a system of drainage is provided by means of which all soil, as it is specially designated, is washed away. In all these cases, as far as the immediate tenant or occupier of a house or cottage is concerned, the sewage, with its attendant value (no supposititious matter, but one which can be easily calculated and expressed in its equivalent of pounds, shillings, and pence), is removed from the premises by means of the drainage; and unless, under some of the more extended disinfecting processes recently introduced, the entire sewage of a hamlet, town, or borough is otherwise dealt with, the value of all these matters as manure runs to waste.

We have now to explain a totally different set of circumstances. In Moule's earth system water is not only not required, but the presence of more than a certain per-centage of moisture materially interferes with the efficient action of the process. Instead of water being employed to wash away, earth is employed to absorb and deodorise. This practical experience proves that it does most thoroughly and effectually; and, therefore, the conditions under which a closet has to be constructed are totally different in detail to those given in our preceding papers. It has been ascertained by repeated experiments on an extended scale that about a pint and a half of dry earth thrown on to the surface of a vessel containing what is usually called an ordinary "dejection" is amply sufficient in quantity to absorb all noxious effluvia and ordinary gas products; and the objects of the special patent are the mechanical means adopted to apply this first principle efficiently in the necessary detail.

The dryness of the earth used and its absorbent qualities are the first requisite. Sand, especially of the description called by architects and engineers "sharp," is useless, because it is non-absorbent; the sharper, in technical phrase, the sand is—the more fragments of quartz or comminuted flint it contains—the more its powers of absorption and deodorisation are diminished, and the less fit does it become for the special object under notice. Dry loam finely powdered, or dry clay in a similar condition, are the materials that only should be used; and there is this curious feature, that they may be re-dried after each operation, and this without any objectionable result, and when dried used again. This may be repeated continuously, even up to twelve or more times, each time considerably increasing the value of the material as a manure. In the sequel we intend to quote various figures from competent authorities as to the value of the result thus obtained.

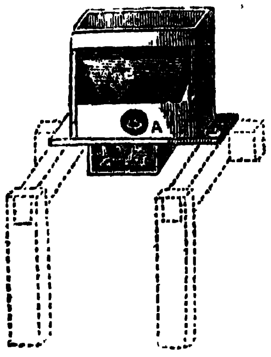


Fig. 30.

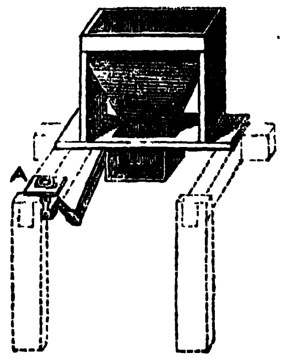


Fig. 31.

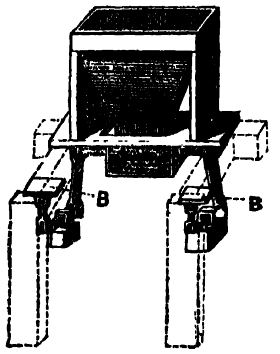


Fig. 32.

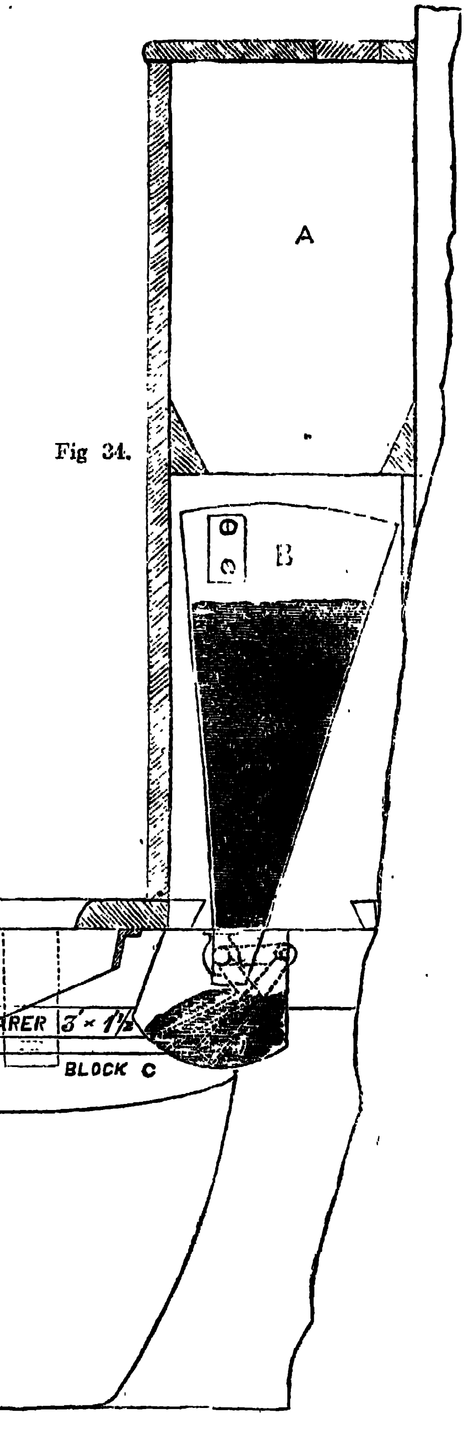


Fig 34.

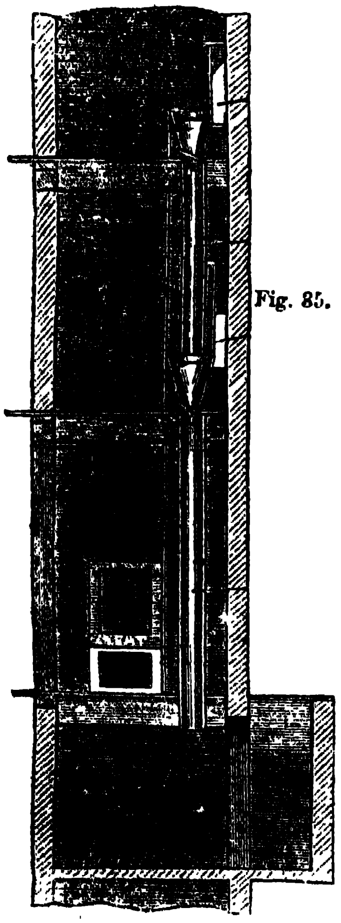


Fig. 35.

The general principle of the patent thus explained—i.e., the employment of earth as an absorbent in place of water as a diluent—we may proceed to say that the use of these closets is legalised by the new "Sanitary Amendment Act," of July 31st, 1868, and that, therefore, there is no statutory reason against their general introduction. It will be evident that in many situations where water is not easily procurable, or where the general arrangements for water-supply, as understood in our metropolitan and provincial towns, is incomplete, their introduction will be attended with advantage. In large and crowded city districts, where there is already a complete organisation under the present system, the same opening does not exist, and difficulties lie in the path of the extended introduction, not on the ground of any defect in the general principle adopted, but only arising from the fact that the necessary facilities for the rapid removal and utilisation of the resulting products are not at hand.

For small towns, hamlets, and villages with deficient water-supply, of which there are so many throughout the country, the system may be safely recommended, as here not only do the facilities exist for readily obtaining a supply of dry earth or loam at a moderate outlay, or no outlay at all, but the field for the utilisation of the products lies at the very door, in the garden or the field adjoining.

Having thus dealt with the general principle, we now proceed to detail. The outward appearance of the closet in construction is exactly in accordance with our usual habits; seat, riser, and lid may be taken as identical with those in every-day use; but here the resemblance ends. Instead of the almost endless system of pipes, the cistern, the traps, the valves, etc. etc., usually required, the only requisite is a vessel in the form of a hopper, made generally in galvanised iron, to contain the dry earth, which is the absorbing and deodorising agent. The subjoined sketches will show the form in which it is applied, and the various mechanical working details will now be explained.

Fig. 30 represents the simplest form of closet of this description, showing the vibrating hopper, the handle that moves it, and the bearers that carry the seat and riser of an ordinary closet. The general arrangement, the space required, and the mechanical action, will be explained in some of the following cuts. A is the handle, by means of which the vibrating hopper, B, discharges the requisite volume of dry earth into the receiver below. In Fig. 31 the principle is the same, but instead of the direct pull from the handle the matter is so arranged that by means of a lever an action is obtained similar to that of an ordinary closet. The pull-up handle is at A. Fig. 32 is an adaptation of the same principle to a self-acting closet, as it is technically termed—*i.e.*, one in which, by the hinged action of the seat itself, by the simple weight of the body, the same result is obtained as by the simple handle (Fig. 30) and the pull-up action (Fig. 31). B, B are the plates attached to the seat, which, rising by a self-acting motion when relieved from weight, discharges the requisite quantity of dry mould by the methods we shall now describe.

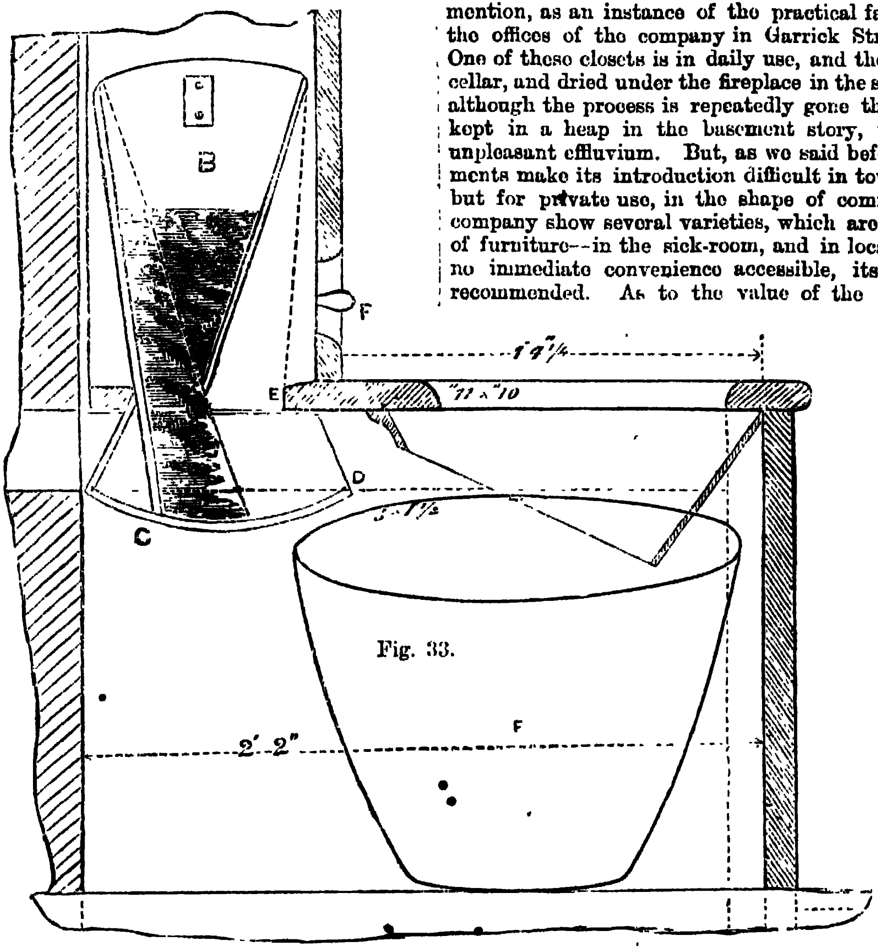


Fig. 33.

In the section in Fig. 33, B shows the hopper containing the dry earth, with the handle, as shown in Fig. 30. When the handle is pulled the vibrating hopper is moved forward to the dotted line indicated by the point E, the bottom edge traversing the line from C to D, and discharging the certain quantity of loose earth into the receiver, F. On the handle being pushed back, a fresh charge of earth falls from the hopper, and it may be used again immediately.

We next give another arrangement of the same kind (Fig. 34), in which the vibration given to the hopper is only a quarter of an inch, with a view of loosening and shaking down the dry earth, the discharge into the receiver being made by the "chucker," as it is called, fixed at the lower mouth of the hopper. The shaded lines show the position of the earth when the closet is at rest, and the dotted line at point C indicates the extent of the motion of the chucker, which resembles in its action a hinged scoop. In this case an arrangement is also shown by which a fixed reservoir, A, is provided above the hopper, B, which can be filled with earth at stated intervals, and thus keep the hopper supplied.

Having, then, in the preceding remarks practically illustrated the matter in hand, we will now proceed to give one or two cautions as to the use of these closets.

1. The earth must be dry and sifted.

2. One charge must always be thrown into the receiver before use.

3. No slops must be thrown down.

4. In every case, either with pull or handle, or self-acting, the action should be given with a jerk, so as to throw the earth freely forward.

With regard to the drying of the earth after use, we may mention, as an instance of the practical facility of the process, the offices of the company in Garrick Street, Covent Garden. One of these closets is in daily use, and the earth is kept in the cellar, and dried under the fireplace in the show-room itself; and although the process is repeatedly gone through, and the earth kept in a heap in the basement story, there is no trace of unpleasant effluvium. But, as we said before, existing arrangements make its introduction difficult in towns on a large scale; but for private use, in the shape of commodes—of which the company show several varieties, which are really elegant pieces of furniture—in the sick-room, and in localities where there is no immediate convenience accessible, its use may be safely recommended. As to the value of the resulting manure in country districts, Mr. Gadsden, who farms 600 acres of land in the neighbourhood of Halton, "has no hesitation in estimating its minimum value at £3 per ton." Mr. Taylor, of Dorchester, a manufacturer of agricultural implements, and a manure merchant, supplies the earth for the closets and urinals of the Dorset County School, and he considers the value of the manure, when used but once in the closet, to be worth £2 to £3 per ton. He also considers that it increases in value in proportion to the number of times it passes through the closet. Similar opinions may be quoted in great numbers.

As instances of the practical use of the principle on a large scale, we may quote the Camp at Wimbledon, Broadmoor Criminal Lunatic Asylum, the County School at Dorchester, and many others. Under date 11th of July, 1867, the Government authorities of India write: "Not only has Mr. Moule's system been very generally adopted, but it has been found to be a public benefit of great value." Into the details of its application to urinals, public and private, slops, kitchen waste, and foul water generally, our space will not allow us to go. We conclude with an illustration (Fig. 35) showing how this principle can be adapted for use on different storeys and at different levels, and the products received in a vault in the basement. Our readers who are familiar with drawings will readily understand the illustration without our explaining the details.

For every and all situations, or to supersede our present method of flushing and water-supply, it would be Utopian to recommend the earth-closet system; but we may say, without hesitation, that under many conditions its introduction would be attended with manifest advantage to the public.

MINING AND QUARRYING.—XXIV.

BY GEORGE GLADSTONE, F.C.S.

LEAD.

SUPPLY OF ORE—GENERALLY ARGENTIFEROUS—GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION—AGE OF LEAD WORKINGS—CHARACTER OF LEAD VEINS—DRESSING THE ORES—ASSAYING.

In the mining and metallurgy of lead, Great Britain takes the first rank amongst the nations of the world, about one-half of the entire supply of this metal being the produce of the British Islands. While speaking of lead too, it is impossible to pass unnoticed the remarkable fact that silver, in greater or less quantity, is almost, if not always, associated with it; so that although silver mining as a distinct operation does not exist in this country, Britain ranks second only to Spain among the nations of the Old World in respect of the production of this precious metal.

It will be impossible, therefore, in speaking of lead, to avoid frequent reference to silver, though the writer will endeavour to keep the two subjects as distinct as possible.

It seems now to be conclusively established that gold also is always associated with lead, though in such small quantity as rarely to be worth consideration.

There is but one ore of lead which is of commercial importance, the sulphide (PbS), commonly called galena; and the metallurgic processes we shall describe will therefore relate to this ore alone, though many other combinations exist in Nature. The latter are interesting rather as mineralogical specimens: they never occur in England in sufficient quantity to render any special metallurgical processes necessary. The commonest of them is cerussite or lead spar, which is a carbonate of lead, forming large, transparent, and generally colourless crystals, or sometimes fibrous or earthy masses. The sulphate occurs in spots where the sulphide has been affected by the action of the weather, but where no carbonate of lime has been present to convert it into the preceding. The carbonate accordingly is generally found where the lodes of galena occur in the sedimentary limestone rocks, and the sulphate in the older argillaceous deposits. The phosphate and arsenate of lead are frequently associated near the outcrop of the lead veins.

Galena occurs in this country principally in the clay slates and limestones ranging from the Lower Silurian to the Carboniferous formation inclusive. The latter rock has hitherto supplied about two-thirds of the entire produce of the British Isles, though recently some very rich deposits have been opened up in the Lower Silurian rocks of Montgomeryshire and Cardiganshire. Thus the great lead district of the North of England, of which Alston Moor is about the centre, lies in the Carboniferous limestone; that of Derbyshire in the same. The long-wrought Welsh mines, which are also remarkably rich, are partly in the Carboniferous limestone and partly in the Lower Silurian slates; those of Devonshire and Cornwall are in the killas or clay slate of the Devonian age; those of Lanarkshire and Dumfriesshire in the same; those of the Isle of Man in Silurian limestones; whilst the Irish form an exception to the rule, and are chiefly in granitic rocks.

On the Continent there are large deposits in Germany, Sweden, Spain, France, and Greece. Some of those in the two former are, however, so remarkably rich in silver, that the mines are actually worked principally for the sake of the latter metal; the lead, though of course far greater in bulk, being, as it were, only a secondary product. A very large district in the United States of America is rich in lead ores, and as the population increases in that region (extending both westward and southward from Lake Michigan), the working of these is attracting increased attention; the day indeed is probably not far distant when the United States will be one of the largest lead-producing countries in the world.

The history of lead-mining in this country goes back to a remote antiquity. There is no question that lead was extensively worked by the Romans; reference to its abundance in Britain is not uncommon in their historical writings; many of the old workings are situated in districts which they occupied, and indubitable Roman remains have been found in them. Moreover, pigs of lead of Roman age have frequently been disinterred, and there is even strong evidence that the working of the lead mines has been continuous from that period till now, in the curious fact that the ancient pigs are of the same size and form, and bear the same distinguishing marks as those of the same district in the present day. Lead, too, was very extensively used by the Romans, and they seem to have been well acquainted with a variety of purposes to which it could be applied with advantage. Thus, in visiting the houses of the luxurious inhabitants of ancient Pompeii, the traveller will now find behind the elegant fresco paintings that adorn the walls of the reception-rooms, that a layer of sheet lead has been placed between the brickwork and the stucco to preserve the latter from damage by wet. In our metallurgical processes it is evident that we have considerably improved upon the ancients, so that the refuse slags from their furnaces are often found to be rich enough in metal to be re-smelted with advantage. Thus in some parts of Somersetshire where the ore is not worked now, there are smelting establishments for the sole purpose of using up the refuse from former works; and a considerable portion of the lead now manufactured in Spain and Greece is in like manner derived from what was thrown aside as valueless by the ancients.

The lead mines in this country are rarely of any great depth. Some of those in Northumberland, where the rock is liable to very great throws in consequence of the whin dykes which disturb that part of the country, are 600 feet deep, but they are generally much shallower. One or two of the mines in Devonshire are of considerable depth. On the Continent, however, there are several which are remarkable for their great depth. The Samson mine at Andreasberg, in the Harz district, for instance, is no less than 2,733 German feet deep, while several others in the immediate neighbourhood are of scarcely inferior depth.

The ore occurs in regular lodes, but these are often spread out into what are called flat veins. These are masses of lead ore which have penetrated from the lode itself between the bedding of the limestone; they never extend any great distance from the true lode, but often contain within a comparatively small space a large mass of metal. If a bed of sandstone should part two layers of limestone which is traversed by a metalliferous vein, the portion flanked by the sandstone will be found to be very much poorer in metal than that on either side of it. In Derbyshire and other places a lode is often cut off entirely for a space by the intrusion of a trappean rock; but unless the intruder forms too thick a mass to render it worth the expense, the miner will cut through it for the sake of reaching the lode again on the other side.

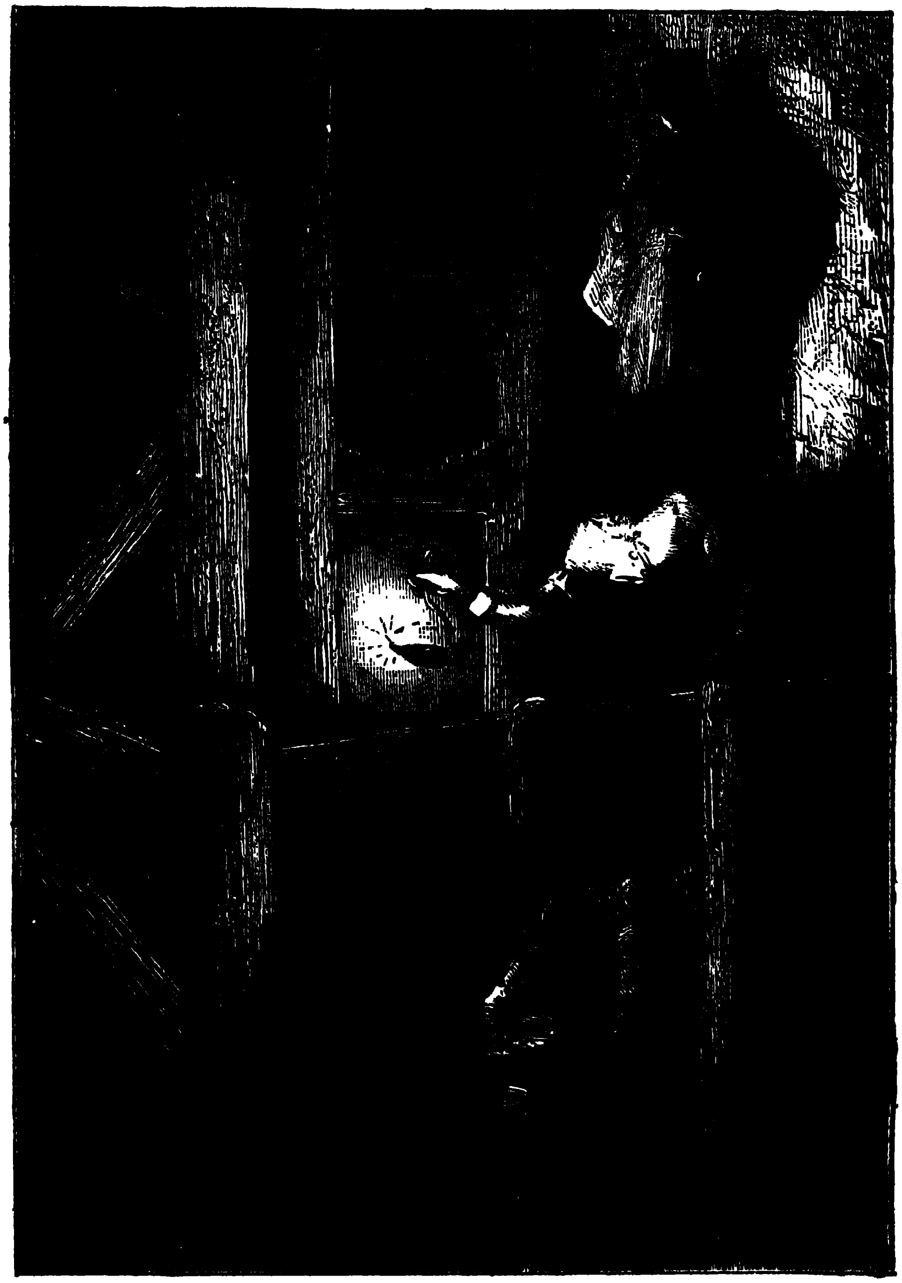
The veins of galena are of very various thickness; sometimes they are split up into parallel branches, connected by thin strings or leadings of ore; at other places, as at Hudgill Burn, there is a solid vein seventeen feet thick. The character of the lodes is very similar to those already described under tin and copper; except that the galena is not diffused through the gangue, as in the case of the former. The lead ore occurs in a massive crystalline form, associated with layers of sulphate of baryta (called cawk in Derbyshire), calcareous and fluor spar, in the Carboniferous rocks; and more commonly with quartz in the older formations. The fluor spar is especially prevalent in Derbyshire, and it is valuable in metallurgical operations as a flux.

The general direction of the lodes is east and west; though there are several notable exceptions. Thus at Holywell, in Flintshire, a very strong lode occurs in the cross course; and some of the rich silver-bearing lodes of the Isle of Man also run north and south. In Devonshire several lodes take the same direction, and at the point of intersection with the east and west veins they are usually highly argentiferous; they are rarely found to approach closely to the eruptive rocks as those of tin and copper do.

There are also some deposits of lead ores, principally a mixture of the sulphide and carbonate, not much worked in England, but to a considerable extent on the Continent, which are quite different in their character. They occur, too, in a rock of more recent formation, the New Red or Trias. The copper-bearing stratum of Alderley Edge, in Cheshire, contains particles of lead ore disseminated through it; and sandstones of the same age in other parts of the country present occasionally the same peculiarity. In Rhenish Prussia there occurs a very valuable deposit of a similar character. The sandstone bed is about 120 feet thick, but only some layers of this are sufficiently permeated with the grains of galena to be worth excavating. In some places it is quarried, and in others the workings are carried underground. At Kommern alone upwards of 1,200,000 tons of the sandstone have been excavated in one year, yielding about 22,000 tons of dressed ore: it is argentiferous, though only yielding a low per-centage of silver.

Lead ore, on being brought to "grass," has to be dressed in order to prepare it for the smelting operations; and the processes which it has to undergo for this purpose bear, at some establishments, a considerable resemblance to those already detailed when describing the dressing of tin ores. It is first sorted and cleaned, in the course of which the lumps of foreign ingredients, spar, baryta, etc., are thrown aside; then it is crushed or ground to a coarse powder, which is usually done now by passing it between a pair of cylinders turning in opposite directions, and driven by water-power. The cylinders are fed with ore from a hopper above, into which the contents of the wagons are tipped as they are drawn from the mine: the hopper is subjected to a slight vibratory motion by the action of the machinery with which it is connected, and this is sufficient to keep up a constant supply of ore to the cylinders, and to prevent the aperture at the bottom of it from becoming clogged. A small stream of water also aids this process, and afterwards passing over the cylinders prevents them from becoming overheated. The latter are made of iron, and are case-hardened; they are not rigidly fixed in their place, so that if a piece of unusually hard material should get between them, the machinery shall not be brought to a standstill or become deranged; but the cylinders will yield place just sufficiently to allow such refractory piece to pass through. If the rock in which the ore is deposited be of a very hard nature, the use of stamps is generally resorted to, in place of the grinding process. The stuff is usually reduced by the crushing mills to a sufficient fineness to pass through a sieve containing nine holes to the square inch, which, when done by water-power, will not cost more than about 2½d. per ton.

After the ore has thus been crushed or ground, the washing takes place, which is performed by passing a stream of water through the ore, in the same way as the tin ores are separated from the earthy ingredients, a description of which will be found in Article XVI. In some foreign countries, especially in such as the Harz district, where the ores are so valuable on account of the silver contained in them, this operation is carried to a very high state of perfection, and the most improved forms of frames are employed; the ores too are there crushed much finer than is usual at English works, or is even thought desirable by our smelters. The very considerable specific gravity of pure galena, 7·6, enables the washers to separate not only the earthy portions, but also most of the metallic substances which may be associated with it: argentiferous ores require greater care in the washing, as the sulphide of silver is of less specific gravity than that of lead.



MINERS IN THE HARZ MOUNTAINS.

The ore being now ready for the smelter, the most ready mode of ascertaining the quantity of metal contained in it is to make the assay in an iron pot instead of an earthen crucible, the metal of the pot assisting in the separation of the sulphur from the ore. The sides of the pot should be about half an inch thick, and the bottom rather thicker still; it should be hammered out of a solid piece of iron, so as to have a smooth interior surface without any seams. Preparatory to charging it, the pot should be put in the furnace and heated to dull redness. It should then be removed from the fire for a moment, and filled with a mixture of ore and flux, the constituents and proportions of which will depend a good deal on the richness or otherwise of the ore to be assayed. Some recommend a mixture consisting of $\frac{4}{11}$ of ore, a similar quantity of carbonate of soda, $\frac{2}{11}$ of pearlash, and $\frac{1}{11}$ of bitartrate of potash, upon the top of which a little borax should be sprinkled. If a rich sample is being operated upon the mixture may consist of equal parts of ore and carbonate of soda, with a tenth part of argol; but for poorer samples, the carbonate of lead should be reduced by about one-third, and its weight replaced by borax. The pot must then be covered down, replaced in the furnace, and heated up to a full red. While at its full heat, the pot is removed from the fire, and the charge poured into an iron mould which has been rubbed over with plumbago and warmed; on cooling, a button of lead will be found at the bottom. The weight of this will give, by calculation, the per-centage of metal in the ore.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XII.

BY E. WYNDHAM TARN, M.A.

IN our last two papers on this subject we gave the measurement of dimensions of joiner's work and ironmonger's fittings throughout a small house consisting of a ground floor, first floor, and second floor: in the present paper we proceed to give the abstract of these dimensions. In the first part of our abstract, which appears in its entirety on this page, all the *superficial* work, or work of which superficial measurement is required, is brought together—namely, the floors, sashes and frames, doors, shutters, stairs, etc.; then measurements of skirtings, friezes, dresser-top, etc., which are regulated by the thickness of the deal of which they are made; and lastly, the various fittings which from their conspicuous position, or for appearance' sake, require to be made of mahogany. Following this we next take all the various parts of the fittings in deal and mahogany that are measured by the *run* without reference to length, breadth, or thickness; then we collect together all fittings measured by numbers; and lastly, the ironmongery and fixings. It will be manifest even on the most cursory inspection that the preparation of an abstract of dimensions is a piece of work which requires great care and attention, and as an item may readily be omitted where so many demand consideration, it is almost needless to remark that the work should be checked carefully. For the sake of practice, the student should take the dimensions given under each branch of the building trade in turn, prepare abstracts from them, and then compare those of his own making with the abstracts that we have furnished.

ABSTRACT.

SUPERFICIAL.

FLOORS.	SASHES AND FRAMES.	DOORS.	SHUTTERS.	STAIRS.	¾ IN. DEAL.	1 IN. DEAL.	1¼ IN. DEAL.	1½ IN. DEAL.	MAHOGANY.
2 ct. w. batten folding. ft. 100)217 0 2 sq. 17 ft. 1¼ in. yell. batten strt. jt. ft. 100)187 0 1 sq. 87 ft. 1½ in. y. tongd. i. tongues. ft. 100)196 2 1 sq. 96 ft.	Dl. cased frame, o. sk. sill, 1½ in. ov. sash, dble. hg., br. pulleys, w. lines, i. wts. ft. 15 9 Dl. cased frame, o. sk. and weathd. sill, 2 in. dl. lamb's-tongue sash, dble. hg., br. pulleys, pat. lines, i. wts. ft. 22 0 Ditto, ditto, ovolo sash. ft. 29 8 Solid oak rebd. and mo. frame, 4 × 3, mullion and transom, mitred, bd. and weathd. sill, 2 in. lamb's-tongue casement, circr. on plan, ¾ in. rise. ft. 35 9 2 in. oak ov. fanlight, circr. head. ft. 7 0	1¼ in. 2 pl. sqre. ft. 18 6 1¼ in. 4 pl. mo. and sqre. ft. 16 6 1½ in. sqre., 4 pl. ft. 17 11 2 in. mo. b. sides, 4 pl. ft. 19 6 22 9 42 3 2½ in. oak, 6 pl. boln. mo., lower pl. bd. flush. ft. 26 3	1¼ in. 2 p. bd. fl. and sqre., hg. with br. pulleys, pat. lines, lead wts. ft. 35 9 1¼ mo. and bd. fl. in 2 pl. folding. ft. 15 2 1¼ in. bd. fl., and sqre. bk. flaps. ft. 13 0 1¼ in. ppr. boxings. ft. 10 3 Revolving wood, with worm and wheel gearing. ft. 105 4	1¼ in. y. dl treads, 1 in. risers, glued & blocked to close-string, mo. nosg., 2 fir carriages. ft. 66 0 Ditto, ditto, winders. ft. 19 3 1½ in. y. dl. treads, 1 in. risers, mitred to cut-string, glued and blockd, mo. nosings, 2 fir carriages. ft. 69 11 Ditto, ditto, winders. ft. 17 11 1½ in. rebd. and bd. outer string, cut and mitred to rise. ft 13 9 Ditto, ditto, wreathe. ft. 1 6 1½ in. rebd. and bd. close string. ft. 11 11 1¼ in. wall-string. ft. 20 0 15 0 35 0 Ditto, ditto, ramp. ft. 7 0 12 0 19 0	W. 1 s. and framed. ft. 5 8 6 8 9 7 21 11 W. 1 s. and bdd. ft. 2 3 W. 1 s. rebd and bdd. ft. 8 4 W. b. s. and devetd. ft. 7 6 W. b. s. and tongd. ft. 14 0	W. 1 s. and tongd. ft. 10 2 17 6 4 0 31 8 W. 1 s. and rebd. ft. 8 9 13 7 15 3 9 7 9 7 4 6 4 10 66 1 W. b. s. frad. and bdd. ft. 3 0 Torus skirtg. ft. 30 5 Sqre. skirtg. ft. 25 8 4 1 29 9 W. 1 s. mo., 1 pl. ft. 7 11 Keyed frieze, jts. feather-tongd., rebd. for soffit. ft. 21 9 W. b. sides. ft. 5 8 6 0 15 0 26 8	W. 1 s. frad. and mo. in 2 pls. ft. 8 3 W. 1 s. frad. and mo., in 1 pl. ft. 9 7 W. b. sides. ft. 3 0 7 7 15 9 26 4 W. b. s. frad. and bdd. ft. 15 0 18 6 5 3 3 6 42 3 W. b. s. cut and dimd. ft. 7 6 Mo. and sqre. framg. ft. 19 0 Ditto, circr. on plan (½ in. rise). ft. 5 0 Mo. and sqre. spandril. ft. 22 9 Mo. and rebd. skirtg. in 2 heights. ft. 53 9	W. 1 s. dble. reb. and bdd. ft. 6 4 6 6 12 10 W. 1 s. dble reb. fram. and mod. ft. 21 11 **2 IN. DEAL.** Clampd. dressertop. ft. 18 2 **SUNDRIES.** Cradling to entab., ploughd. and tongd. blockings. ft. 43 6 Mod. cornice. ft. 24 0	¾ in. w. b. s., Fr. pold. ft. 2 2 1 in. framd. seat and riser, Fr. pold. ft. 11 5 1 bd. flap and frame, Fr. pold. ft. 6 2 1 in. mo. and sqre. framg., Fr. pold. ft. 34 6 1¼ in. counter top, glued and blocked. ft. 25 6 2 in. astragal and hollow folding sash door, dimd. stiles, lower pl. mo. and bd. fl., Fr. pold. ft. 24 6 2¼ in. lamb's-tongue shop sash, Fr. pold. ft. 66 6 Ditto, circr. on plan. ft. 17 6

RUN.

DEAL.

½ in. wrot. stop.
ft.
7 0

¾ in. chamfd. fillet, 2¼ in. w.
ft.
7 8

¾ in. skirtg. grds., pluggd.
ft.
40 6

¾ in. bead.
ft.
3 6
4 3
—
7 9

Sqre. angle staff, plugged.
ft.
20 0
23 0
—
43 0

Drawer runners.
ft.
9 6

Groove.
ft.
13 0
21 0
—
34 0

Groove and tongue.
ft.
48 9

1 in. nosing.
ft.
4 6
6 0
—
10 . 6

1 in. picture grds. plugged.
25 0

1 in. skirtg. grds. plugged.
ft.
43 0
9 7
—
52 7

1 in. dble. bd. pin-rail, 4½ in. w.
ft.
4 6

1 in. arch mo., 2¼ in. w.
ft.
14 0
33 0
4 6
23 6
—
75 0

1 in. ar. mo., 3½ in. wide.
ft.
5 0
21 6
34 0
—
60 6

1¼ in. ditto.
ft
23 6
38 0
15 0
—
76 6

Ditto circr.
ft.
6 6

1¼ in. m border.
ft.
13 0
7 0
—
20 0

Moldg. 4 in. girt.
ft.
9 6

Ditto circr.
ft.
2 6

2¼ in. wrot. and framd. legs.
ft.
12 0

2¼ in. turned nowell.
ft.
15 6

2½ in. mo. hand-rail.
ft.
13 0

MAHOGANY.

Mod. nosing.
ft.
3 6

½ in. skirtg., 4 in. w., Fr. pold.
ft.
7 0

3 in. mo. hand-rail, Fr. pold.
ft.
15 0

Ditto, ditto, writhe.
ft.
3 0

Bdd. door frame, 3″×3″, Fr. pold.
ft.
18 0

Mortise clamp.
ft.
6 0

Headg. joint.
ft.
6 0

Wrot. and chamfd. fillet.
ft.
3 0

NUMBERS.

DEAL.

Housings to string for flyers.
30
15
18
—
63

Ditto, ditto, winders.
3
3
—
6

Ditto to handrail.
15

Ditto to newell.
3
1
—
4

Mitres to 9 in. skirting.
8

Dovetail blockings.
3

Pendants to newell
2

1¼ in. sqre. baluster.
15

1½ in. turned ditto.
30

Returnd. mo. nosing.
15

Cut bracket.
15

MAHOGANY.

Dished hole.
1

Beadd. handhole.
1

Rod. corner to skirting.
2

Fittg. and hangg. flap.
1

Mitre.
4

¾ in quadrant shelf, 9″×9″, on fillets, Fr. pold.
1

NUMBERS (*continued*).

DEAL.

Dovetl. housings for balusters.
30

Rod. corners to shelf.
2
3
1
—
6

Ditto, dresser.
2

O. G. cut ends.
2

Tongd. angles to string.
2

Tongd. and mitred angles to 15 in. skirting.
10

Curtail scroll end to step.
1

Elbow caps.
2

Soffit to boxing.
2

MAHOGANY.

Handrail scroll.
1

Housings in handrail.
30

IRONMONGERY AND FIXING.

HINGES.

1½ in. bt. and bk. flap.
1 pr.
2 „
—
3 pr.

2 in. butts.
2 pr.

2½ in. ditto.
1 pr.
1 „
1 „
—
3 pr.

3 in. ditto.
1 pr.

3½ in. ditto.
1 pr.

1½ in. brass butts.
1 pr.

2 in. ditto.
2 pr.
1 „
—
3 pr.

4 in. ditto.
1 pr.

5 in. ditto.
1 pr.

LOCKS.

Cupb.
1
1
—
2

Rimd., br. furn.
1

6 in. mort. china furn.
1
1
—
2

10 in. draw-back.
1

Patent latch.
1

Brass escutcheon.
2

FASTENINGS.

Br. sash fastg.
1
1
1
—
3

Br. casement fastg.
2

8 ft. shutter-bar and plates.
1

Br. rack chain.
1

Br. knob turnbuckle.
1
1
1
—
3

Br. thumb-screw and plates.
1

Br. hook and eye.
2

BOLTS.

10 in. br. barrel.
2

SCREWS.

Handrl. scr.
3

Scr. bolt to newell.
2

SUNDRIES.

Screw nut and joint to newell cap.
1

C. i. newell.
1

C. i. shelf-bracket.
2

Japd. clk. pins
6

China finger-plates.
2 pr.

Ebony drawer knob.
4

Br. sk. fl. rings.
2
1
—
3

Br. hooks.
3 doz.

SEATS OF INDUSTRY.—XXVIII.

LIVERPOOL (*continued*).

BY WILLIAM WATT WEBSTER.

THE docks of Liverpool are the most extensive and convenient in the United Kingdom, and have been both an important cause and an important effect of its commercial prosperity. Mention has already been made of the first dock constructed at the port, in the beginning of the eighteenth century; but previous to that date efforts had been made to improve the navigation of the Mersey, and the efficiency of the harbour of Liverpool. In 1694 Thomas Patten, of Warrington, widened the river, and made it navigable from Runcorn to Warrington. The old dock, which occupied an area of less than three and a-half acres, soon proved too small for the wants of the town, and was subsequently filled up; the new custom-house being built on its site.

In 1734 the Salthouse Dock was commenced, but it was only opened in 1753; and in 1761 an Act was obtained for building George's Dock, which was completed in 1771. Authority was obtained in 1784 for building two other docks, the King's and the Queen's; the former was opened in 1788, and the latter in 1796. The Prince's Dock, one of the largest on the Mersey, being 500 yards in length, and covering an area of nearly twelve acres, was completed in 1821. Since that date several enormous docks have been constructed; among others the Huskisson, which covers an area of 15 acres, 993 square yards; and the Brunswick, which has an area of above twelve acres; while the old docks have been improved and extended. Two new docks were finished in 1867. Liverpool now possesses about fifty docks and basins, extending along the margin of the river for about five miles; having nearly seventeen miles of quay space, and covering a total area of upwards of 700 acres, exclusive of the docks of Birkenhead on the opposite bank of the Mersey, which are four in number, including Wellesley Pool, which is considered the finest dock in the world. The docks of Liverpool were principally erected under the superintendence of Jesse Hartley, Esq., and are justly regarded as one of the great engineering triumphs of the century. Many of these docks are surrounded by spacious warehouses; those enclosing the Albert Dock, for instance, having cost £358,000, while the dock itself cost £141,000. An admirable feature of the Liverpool harbour consists in its two large floating landing-stages, one of which is 1,002 feet in length, 82 feet in width, and 4,500 tons in weight.

LIVERPOOL FROM THE MERSEY.

The completion of the Liverpool and Manchester Railway, which was opened in September, 1830, and cost £876,000—more than double the estimate laid before Parliament—marks an important stage in the progress of Liverpool. By an agreement entered into between the Bridgwater Canal Company and the Leeds and Liverpool Canal Company, the former acquired exclusive possession of the traffic between Liverpool and Manchester, although it was unable to forward the goods entrusted to it with the promptitude the trade required. Mr. Huskisson complained in the House of Commons that "cotton was sometimes detained a fortnight in Liverpool, while the Manchester manufacturers were obliged to suspend their labours; and goods manufactured at Manchester could not be transmitted in time, in consequence of the tardy conveyance." To remedy this grievance, an enterprising Liverpool merchant, named Mr. Sanders, in 1820 started a project for laying down a tramroad between the two towns, and he was soon joined by other merchants who were not interested in maintaining the monopoly of the canals. This scheme resulted in the Liverpool and Manchester Railway, which, however, had to contend against strong prejudice and powerful vested interests. Among the merchants who gave evidence before a Committee of the House of Commons in favour of the railway, in 1825, two deserve a place in this paper, because they exercised a potent influence on the trade and general well-being of Liverpool. One of these merchants was John Gladstone, the father of the present Prime Minister of England; and the other was William Brown, the founder of the Liverpool Free Library; of whom Cobden said in 1844, that he "held in his hands one-sixth part of the trade between this country and the United States." From the evidence of Mr. Gladstone we learn that upwards of 10,000 vessels, with cargoes weighing in all 1,180,914 tons, entered the port of Liverpool in 1824; and that the dock dues, which amounted to £9,200 in 1787, when he settled in the town, had by 1824 increased to fifteen times that amount. The entire value of the goods received and shipped by Mr. Brown about this period amounted sometimes to £1,000,000 a year. There were then four lines of ships, sixteen in all, trading regularly between Liverpool and New York; and two lines, comprising eight ships, going to and from Philadelphia. The average value of the cargoes of these vessels was calculated at £50,000, but the goods they carried were in some instances worth three times that amount of money.

At the present time no less than four-fifths of the trade between the United States and Great Britain is carried on through Liverpool, as well as a large portion of the trade with South America and the West Indies; it also possesses a considerable share of the trade with the East Indies and China, although in the latter department Liverpool is surpassed by London. In 1864 the total number of vessels that entered the port amounted to 4,045, of which 2,898, with an aggregate of 1,372,203 tons burden, were British; and 1,147, representing a total burden of 498,292 tons, were foreign. From British colonies there arrived at the port in that year 1,127 British and 106 foreign vessels; while from foreign countries there came 1,771 British and 1,041 foreign vessels. The total value of the exports from Liverpool in 1864 was £72,748,031. In 1866 there belonged to the port 2,998 vessels, of which 2,569, of an aggregate burden of 1,326,317 tons, were sailing ships; and 429 were steamers, with an aggregate burden of 205,664 tons. The exports of the produce and manufactures of the United Kingdom from Liverpool, during that year, represented a total value of £87,486,497, against £41,449.797 from London; and 12,622 vessels, with an aggregate burden of 4,749,428 tons, entered the port. The importation of cattle and pigs into Great Britain from Ireland, which in 1866 amounted to upwards of £8,000,000, is carried on to a great extent through Liverpool.

For many years Liverpool has been the principal point of departure for emigrants from Great Britain and Ireland, and it is now the greatest port of emigration in the world. Large bodies of emigrants from Germany, and other parts of the Continent, find it cheaper to set sail from Liverpool for their various destinations, than from any port in their own countries. Steamers of large size, unrivalled speed, and with excellent accommodation for passengers, leave the harbour almost daily for New York, and other ports of the United States; and a magnificent fleet of steam-vessels, of unexampled magnitude, are engaged in trade with New York, Boston, Halifax, Rio de Janeiro, Buenos Ayres, Lima, Lisbon, Oporto, and the Mediterranean.

The manufactures of Liverpool consist chiefly of ship and boat building, cable and anchor casting; the construction of marine engines; and other branches of industry connected with the sea. Shipbuilding has declined during recent years, and Liverpool is now inferior in this respect to Sunderland, and to her great transatlantic rival, New York. The manufacture of soap is more extensively carried on in Liverpool than in any other town in the kingdom, and it is also one of the chief centres of the manufacture of chronometers, watches, and watch movements, of which latter large quantities are annually exported. In and near the town there are large distilleries of tar, turpentine, and whiskey; extensive rice and flour mills, saw mills, sugar refineries, cigar factories, roperies, and glass and alkali works.

Liverpool has nearly doubled its population every twenty years since the beginning of the present century. In 1861 its population numbered 443,938, and in 1871 it contained 493,346 inhabitants. Up to a recent date Liverpool consisted of narrow, irregular, ill-paved streets, lined with dull heavy-looking houses, and was regarded as one of the most unhealthy towns in England; but within the last forty or fifty years, and especially since the passing of the Local Sanitary Act of 1846, great improvements have been effected; and there are now few towns in Great Britain with wider, more handsome, and better-cleaned streets, and more substantial and sumptuous houses. In 1846 the water-supply, which before that date had been in the hands of private companies, who derived it from wells sunk into the red stone, was transferred to the Corporation at a cost of £554,807; and in the same year the latter obtained an Act authorising new works for the conveyance of water from a distance of twenty-six miles, which were opened in 1856, and cost £700,000. A new charter was granted to Liverpool by William III. in 1695, which was confirmed with a few emendations and additions by George II. and George III.; and by this charter the town was governed down to the passing of the Municipal Reform Act in 1835. By that measure the town was divided into sixteen wards, and placed under the government of a mayor, fifteen other aldermen, and forty-eight councillors. The parliamentary borough was enlarged by the Boundary Act, so as to include the out-townships of Everton, Kirkdale, West Derby, and Toxteth Park.

The principal public buildings in Liverpool are the Town Hall, St. George's Hall, the Exchange, and the Revenue Buildings. The Town Hall, founded in 1749, is an elegant Grecian structure; a handsome dome, supported by Corinthian pillars, and surrounded by an open gallery, rises from the centre of the building. The Exchange Buildings, which form three sides of the square enclosed by the Town Hall, were begun in 1803, and completed in 1809, at a cost of £110,840. In the centre of the square, a bronze statue of Nelson, designed by Wyatt, and executed by Sir R. Westmacott, was erected in 1813, at a cost of £9,000. The Revenue Buildings cover an area of 6,700 square yards, and comprise the office of the Inland Revenue, the office of the Commissioners of the Docks, and the Post Office. St. George's Hall is a sumptuous building in the Corinthian style; one portion of it is set aside for the Assize Courts, and the other for a concert-room, which is capable of accommodating an audience of 1,200.

There are about 150 churches and chapels in Liverpool; a third being connected with the Establishment, about 14 being Roman Catholic, 21 Presbyterian, 15 Independent, 16 Wesleyan, 2 Jewish, 1 German, and 1 Greek. Liverpool is provided with an unusual number of charitable and benevolent institutions, the most prominent being the Royal Infirmary, the Northern and Southern Hospitals, the Industrial Schools, and the Blue Coat Orphans' School. Among the principal educational, literary, and scientific institutions in the town, besides the Free Library and Museum, already incidentally mentioned, we may note the Botanic and Zoological Gardens, the Observatory, for which a new building was erected at Bidston in 1865, the Collegiate Institution, Queen's College, the Medical Institution, the Royal Institution, the Mechanics' Institution, the Society of the Fine Arts, the Academy of Fine Arts, the Egyptian Museum, and the Exchange, Lyceum, and Athenæum News-rooms and Libraries. Liverpool has several good theatres and concert-rooms, and in addition to the Botanic Gardens it has another fine park at Toxteth. Mrs. Hemans, William Roscoe, and Dr. Currie, the biographer of Burns, are among the most celebrated natives of the town.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXX.—TYCHO BRAHE.

BY JAMES GRANT.

THIS celebrated astronomer was born on the 14th of December, 1546, during the reign of Gustavus I. of Sweden, at Knudstrop, in the county of Schonen, near Helsingborg. When seven years old he was taught Latin; and for five years studied under private tutors. On the death of his father—an event which occurred when Tycho was very young—he was adopted by his uncle George Brahe, who, in 1559, sent him to study rhetoric at Copenhagen. The great eclipse of the sun, which occurred on the 21st of August in the following year, seems to have greatly impressed his mind, as it happened at the precise time astronomers had foretold it; hence, he began to consider astronomy as something divine, and purchasing the tables of Stadius, by studying them he rapidly gained some idea of the planetary system.

In 1562 young Brahe was sent by his uncle to Leipzig to study law, and there, by his acquirements, he manifested indications of wonderful talent. His natural inclinations, however, were not legal; he disliked the dry study of law, and preferred that of the heavenly bodies, and to the latter he applied himself so assiduously, that notwithstanding the injunctions of his uncle or the care of his tutor, to keep him close at the studies for which he had come to Leipzig, he attained a great knowledge of astronomy. With what he could save from his pocket-money he purchased every book he could meet with on that subject, and read them with attention and enthusiasm, procuring ultimately, in cases that puzzled him, the assistance of his private tutor, Bartholomew Schultens. After a time, having procured a small celestial globe, he took opportunities, when Schultens was in bed, and when the weather was clear, to examine the constellations in the heavens, to learn their names from the globe, and their motions from observation.

Returning to Denmark in 1571, his studies and assiduity won him the favour of his maternal uncle, Steno Billes, who, being a lover of learning, gave him a convenient place at his castle of Herritzvad, near Knudstrop, for the erection of a building wherein to continue his observations and have a laboratory. Brahe built another observatory at Wandsbeck near Hamburg, when residing with the Count Rantzau. This edifice is still standing, and a bust of him is placed in one of the upper rooms. But it was at Knudstrop that, in 1572, he discovered a new star in the constellation Cassiopeia. Soon after this, having married a pretty peasant girl far beneath his rank, a quarrel ensued between him and his relations, and it was of a nature so violent that the king, then Frederick II., had to interpose his authority ere a reconciliation could be effected.

By command of the latter, in the following year he began to lecture at Copenhagen on the planetary system; and in 1575 he began his travels, and passing through Germany proceeded as far as Venice, where Luigi Mocenigo, under whom the famous battle of Lepanto was won, reigned as Doge.

Aware that he was coldly viewed by his relations in consequence of his marriage, he resolved to settle at Basle in Switzerland with his wife and children; but King Frederick, loth to lose a man so capable of doing honour alike to Denmark and to Sweden, promised, with a discriminating generosity that did him honour, to bestow upon him for life the island of Huen, in the Sound, between Copenhagen and Landscrona, and usually called by seamen, in those days, the Scarlet Isle. It was very fertile, and is seven miles in circumference. Frederick did more, for, however intolerant in religious matters, he was ever bountiful to the learned: he bestowed upon Tycho Brahe a pension of 2,000 crowns out of his treasury, a fee in Norway, and a canonry in the Cathedral of Roskilde which brought him a thousand more.

In the course of four years Brahe had built in the centre of his island the handsome castle of Uraniburg, which had many splendid apartments; and therein he had an observatory and all his books, mathematical and astronomical instruments. Adjoining it he erected a mill for making paper, a printing house, and laboratories for chemical investigations; but his favourite place for studying the stars was at Stellenburg, an edifice which he erected westward of the castle expressly for the purpose of an observatory. The rest of the isle he laid out in gardens, with fish-ponds, and in every way made it one of the most charming places in Denmark.

There Brahe resided for twenty years, pursuing his astronomical observations with remarkable industry. In these he was usually assisted by ten or twelve intelligent students, whom his generosity inspired him to provide for and keep about him, and whom he instructed in mathematics and astronomy.

In 1589 he received a visit of James VI. of Scotland, who was accompanied by his Lord Chancellor and many Scottish nobles. The king had recently been married at Upsala to the Princess Anne of Denmark, and though the limit of his stay in that country was to have been only twenty days, it extended to six months. James made Brahe many noble presents, and wrote some Latin verses in his praise; and the Scottish Chancellor (afterwards Lord Thirlstone), who had some pretensions to literature in his time, became intimate with him, and spent much of his time at Huen during the winter of 1589.

Brahe's tranquillity, his domestic happiness, and his studies, were all now fated to be destroyed. Soon after the death of his royal patron Frederick, he fell a victim to the envy and malignity of the ministry; they aspersed him to Christian IV., who in 1596 stripped him of his pension, his fee in Norway, and his canonry. He was then compelled, to quit his favourite isle, which was bestowed upon a mistress of the king, and she, in a spirit of mere wantonness, is recorded to have destroyed all his works and buildings.

With his reduced household Brahe now took up his residence in Copenhagen, and with some of his instruments continued his astronomical observations and chemical experiments, until the same malevolence that drove him from Huen procured from Christian IV. an edict to discontinue even these.

Compelled now to leave Copenhagen, the unfortunate Brahe conceived the idea of seeking an introduction to Rodolph II., Emperor of Germany, who was fond of mathematics, mechanics, and chemical experiments—an amiable monarch, who, according to Voltaire, knew everything but the art of government. To pave the way for an interview, Brahe published his carefully-prepared "Astronomiæ instauratæ Mechanica," illustrated with plates, and dedicated it to the Emperor, who thereupon invited him to Prague. Thither Brahe repaired, and was received with the utmost honour by Rodolph, who assigned him a magnificent house, with a pension of 3,000 crowns, and the promise of a permanent fee for himself and his sons. With the latter and his students—among whom was the celebrated Kepler—he settled, in the latter end of 1598, in the Bohemian capital, where he built an observatory, the site of which is now occupied by the mansion of a noble family.

Tycho Brahe had the vulgar weakness, incident to his age, of giving credit to judicial astrology; but this superstition did not render him the less an astronomer, or the less able in mechanics. "His fate," says Voltaire, "was the same with other great men; he was persecuted in his own country after the death of the king his protector; but he found a noble patron in the Emperor Rodolph, who made him ample amends for all his losses, and for the injustice of courtiers."

The famous astronomical tables of Brahe and Kepler bear the emperor's name, being called the Rodolphine Tables, just as those which were made in Spain by two learned Arabs in the twelfth century bore the name of king Alphonso. Brahe did not long enjoy the new ease and affluence which surrounded him, as he died at Prague on the 4th of October, 1601, in his fifty-fifth year.

The apparatus of Brahe was purchased by the Emperor for 20,000 crowns; it remained, however, useless and concealed till the troubles of Bohemia ensued, when the army of the Elector Palatine plundered the city, and in a spirit of barbarism broke his instruments to pieces, and applied the brass and other metals to uses for which they never were designed. His great celestial globe of polished brass was, however, happily preserved and deposited with the Jesuits at Naysia in Silesia, from whence it was afterwards taken, in the year 1633, and placed in the hall of the Royal Academy at Copenhagen.

The family of the great astronomer is still in existence, and has been considered one of the oldest and noblest in Sweden. The present possessor of their great and antique château of Skugkloster, which was built in 1630 by Gustavus Wrangel, one of the most celebrated generals of the Thirty Years' War, is a lineal descendant of Tycho Brahe, and likewise of Count Brahe, who led the centre of the Swedish army at the battle of Lützen, in 1632. The château came to the Brahe family by marriage with that of Wrangel, and there is carefully preserved a portrait of the astronomer, and of the beautiful Ebba Brahe, to whom Gustavus Adolphus was so tenderly attached, and whom he would have made Queen of Sweden, but for the schemes of his mother, who married her by fraud or force to Count Jacques de la Gardie.

SHIP-BUILDING.—XIII.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF IRON SHIPS (*continued*).

THE plates forming the skin of an iron ship are secured to each other and to the frames by means of numerous closely-spaced rivets. These fastenings are made of superior qualities of iron, and are formed (as shown in Fig. 41) by means of rivet-making machines, some of which are most ingeniously constructed. The holes through which they pass are generally punched in the plates and frame angle-irons, and in the outer plates they are afterwards enlarged conically, or "countersunk," as shown in Figs. 39 and 40. The rivets are heated before being put in place, and when driven through from the inside a heavy hammer or "dolly" is held against the head, while workmen outside beat down the point into the countersunk hole; to make good work, the rivet when cool should fill the hole. In cooling it is sure to contract somewhat, and a common rule for ensuring a good fit afterwards is to form the countersink as illustrated on the upper rivet in Fig. 39. The centre, A, of the hole on the inner surface of the plating is joined with the sides of the hole near the common surface, and these dotted lines produced form the sides of the countersink. This rule is, however, often departed from. When "knocked down," the point of the rivet is sometimes made slightly convex beyond the surface of the plate, as in Fig. 39; and in other cases is made flush, as in Fig. 40. Different builders have their own practice on such unimportant matters.

Punching the rivet-holes has been much objected to, on the ground that the plates are weakened thereby, and that it is difficult to ensure the exact correspondence of the holes in overlapping plates and frames. Efficiency in the fastenings obviously depends greatly upon such correspondence being obtained, so that the rivets may pass fairly through the holes; and with care it can be obtained, even when the holes are punched. The other objection to punching, its weakening effect, is not so easily removed, and it has led to the suggestion of drilling instead of punching. As the application of drilling machinery to iron ship-building has not yet been carried far, the much greater cheapness and rapidity of work rendered possible by punching has enabled that operation to keep its place. Should drilling machines be improved, however, so as to enable them to be used economically, it is probable that they will, to a great extent, displace punching, at least in the larger ship-yards; and if steel comes into general use this change is all the more likely to take place, as that material appears to suffer much more from punching than iron does. It is a good plan with steel, if the holes are punched, to anneal the plates afterwards, as the injury done by punching is then greatly lessened.

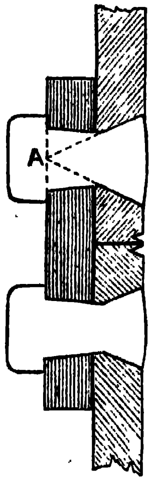


Fig. 39.

Punched holes are not exactly cylindrical like drilled holes, but are a little larger at the side which is most distant from the punch when it is made to press upon the plate, so that the holes are slightly conical, as shown in Figs. 39 and 40; and in making rivets a conical enlargement is formed under the heads to fit them (as in Fig. 41). On this account care ought always to be taken to punch the holes *from the faying surfaces* of plates; that is to say, from the outer surface of the laps of inside strakes, and the *inner* surface of the laps of outside strakes. When this precaution is taken, and the rivets are put in, their sections within the limits of the two plates resemble two truncated cones with a common smaller end. Hence, if by any corrosive action, or other cause, the rivet-heads should be worn away, the rivets would still hold the plates firmly together; whereas if the holes in the inner plates were punched from the inside surface, the rivets would have no holding power independently of the heads. There are many other matters of practical interest in connection with riveting, to which we hope to refer in another paper; but we must now proceed to describe the ordinary methods of arranging the fastenings in the edges and butts.

It may fairly be assumed that the in-and-out plan of plating need only be considered in this connection; and we shall then have to deal with lap-joints for the edges and with flush-joints at the butts. The edges are either "single" or "double" fastened. Single fastening is illustrated in Fig. 42, and is so simple as to require no explanation. Double fastening may be either "zigzag" as in Fig. 43, or "chain" as in Fig. 44. The latter arrangement is the more recent, and is now more frequently used, its chief advantages probably being the uniformity of spacing and the clearness from the butts which it permits in the edge-rivets. On the zigzag plan it will be noticed that a rivet comes directly in the butt, and that long spaces occur in one of the rows of rivets where the frames cross the plates; although this is sometimes obviated by placing two edge-rivets in each frame, it is more usual to follow the arrangement of Fig. 43. In the iron-clad ships of the navy, double chain riveting is always employed for the edges of the bottom plates. In merchant ships a similar plan is usually followed for at least the thicker plating; but when plates of $\frac{1}{4}$-inch or $\frac{3}{8}$-inch in thickness are employed, single-edge fastening is thought sufficient. And there can be little doubt that so far as the strength of the edge-connection alone is concerned, single riveting would answer every purpose; the use of a double row of rivets adding, of course, to the strength, but being rendered advantageous rather by its effectual "closing" of the lap-joint. Thick plates, being much less flexible than thinner plates, of course require more edge-fastening in order to secure the close contact so desirable in water-tight joints. This latter consideration practically regulates the spacing of the rivets in the edges, the "pitch" of which—or their distance from centre to centre—should lie between $3\frac{1}{2}$ and $4\frac{1}{2}$ times their diameter if the joint is to be made properly tight. The breadths of laps required are for single riveting from $3\frac{1}{4}$ to $3\frac{1}{2}$ diameters, and for double riveting from $5\frac{1}{2}$ to 6 diameters of the rivets. To caulk a lap-joint (such as in Fig. 40), it is first necessary to notch the edge of the plate with a suitable tool, and to drive the "burr" thus formed close against the inner plate. This simple operation is found to answer every requirement.

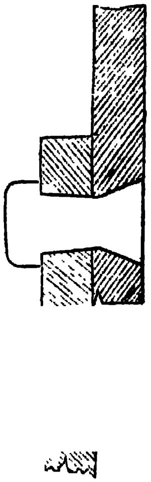


Fig. 40.

The plates are fastened to the frames by rivets spaced from 7 to 9 diameters apart from centre to centre, except in wake of transverse water-tight bulkheads, where the pitch is made about one-half as great, and other special methods are adopted, which will be explained hereafter. The edge-rivets in wake of the frames have to pass through three thicknesses, and more than usual care is required in order to secure good holes for them. On this account it is usual to leave the holes in the frames in way of the laps or "lands" of the plating, unpunched until the plates are fixed, and then to drill them, or else to "bore" them out with a sort of portable punching machine. All the other rivet-holes would be punched in the frame angle-irons before they are put in place, and they should be punched before the frame angle-irons are bent, in order to make thoroughly good work.

Turning now to the fastenings of the butts, we meet with much greater variety and difficulty. At present our remarks will be confined to a description of the principal plans that have been used, and in a future paper we shall attempt to show what are the true principles on which all arrangements of butt-fastenings should be based. Figs. 42—47 illustrate the chief methods adopted, and in each of them the vertical line drawn midway between the frames shows the butt of the plating, the boundaries of the internal butt-strap being shown in dotted lines. In each case also a sectional view is given showing the relative positions of the butted plates, the butt-strap, and the adjacent strakes of plating.

Fig. 42 shows a single-riveted butt of an outer or raised strake: the butt-strap proper being fitted between the edges of the adjacent sunk strakes, and two short supplementary straps, or fish-plates, being fitted over the joints of the strap and the sunk strakes. So far as the arrangement of the riveting is concerned, it will suffice to say that builders are scarcely ever content with single-butt fastenings, and that Lloyd's Rules only permit their use for the thin side plating of poops, forecastles, bulwarks, etc. Single riveting has, however, been used in very many cases, and Mr. Scott Russell has employed it in vessels built on the longitudinal system. It can only give sufficient strength against tensile strains, however, when associated with a good frame-space and a shift of butts giving a large number of passing strakes between consecutive butts; and even when this is the case a practical difficulty is raised on the ground that the butt is not efficiently closed and supported when single riveting only is employed. Respecting the other features of the plan, the use of fish-plates and a butt-strap, it must be stated that they were based upon the belief that it was necessary to strap the butt for the whole breadth of the strake, and that the fish-plates, besides doing this, helped to make the butt water-tight.

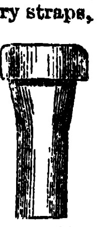


Fig. 41.

Another attempt in this direction is illustrated by the section in Fig. 43, where the strap is actually forged in such a manner as to overlay the whole breadth of the butted plate. This was obviously a very expensive plan, and, as well as the preceding one, was not at all necessary, for every purpose is now found to be served by simply fitting the straps to the outside strakes between the edges of the inside or sunken strakes, as shown in the section in Fig. 44. With inside strakes it is, of course, easy to make the straps extend across the full breadth of the butted plates, and this is commonly done as shown in the sections of Figs. 45—47.

Reverting to Fig. 43, we have an example of a "double zigzag" butt-fastening, such as was formerly very generally employed, but has now given place, to a great extent, to "double chain" riveting like that shown in Fig. 44. Chain riveting is considered to be rather stronger than zigzag, and is now much used in merchant ships, while it is exclusively employed in the ships of the Royal Navy. In fact, the general arrangement of fastenings in the bottom plating of the latter would be fairly illustrated by Fig. 44.

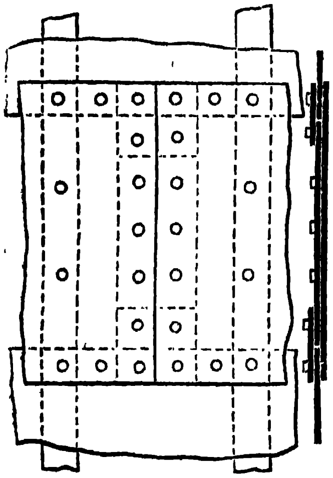


Fig. 42.

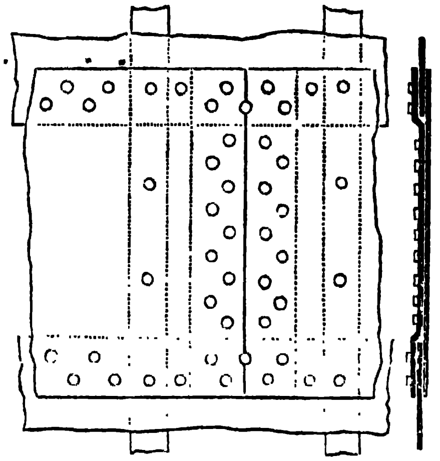


Fig. 43.

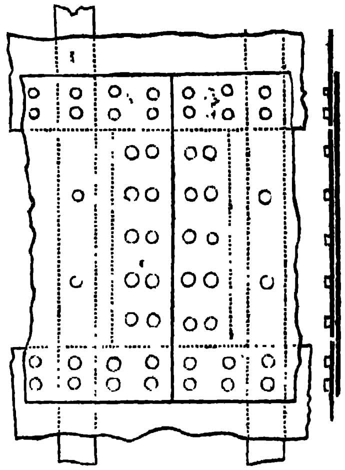


Fig. 44.

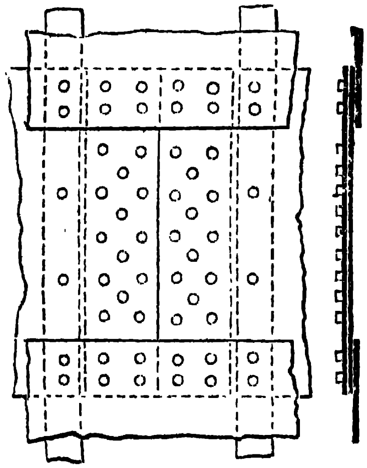


Fig. 45.

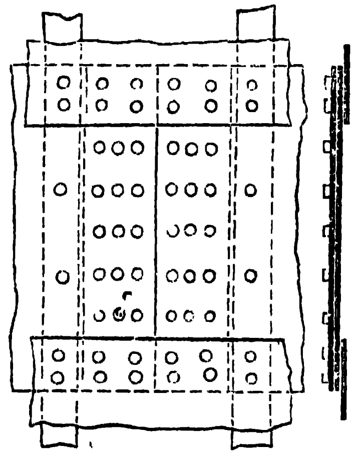


Fig. 46.

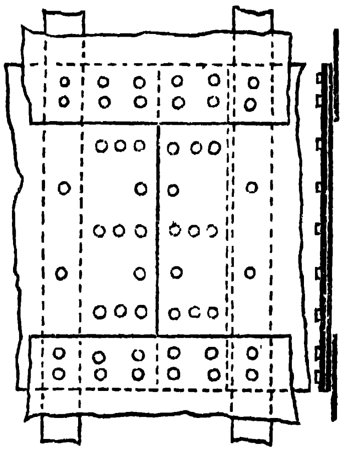


Fig. 47.

An example of a treble zigzag riveted butt is shown in Fig. 45, and one of treble chain riveting in Fig. 46. The former is but rarely used; and the latter, although it has been strongly advocated by some high authorities, has not been much employed. Sheer-strakes, middle-line keel-plates, and a few other longitudinal pieces, are almost the only cases in which treble chain riveting is adopted; but one or two builders have even gone so far as to use quadruple chain riveting in securing the butts of the sheer-strakes in vessels of unusual length. This seems quite unnecessary, however, and double chain riveting, associated with a good shift of butts, can be made to answer all essential requirements in fastening the butts of the outside plating. In Fig. 47 a plan not often used is illustrated, and will be seen to differ from that in Fig. 46, in having the alternate rivets left out in the two rows on each side most distant from the butt. Sometimes, and more commonly, only the outer row of rivets on each side of the butt is thus treated. In either case the object of the plan is either to distribute the fastenings well, or to secure the butt with a greater number of rivets than could be worked in if double chain riveting were used. The spacing of the rows of rivets nearest the butt must, of course, be as close as before—*i.e.*, from 3½ to 4½ diameters—in order to allow of the butt being caulked.

The operation of caulking a butt-joint is illustrated in Fig. 39. Notches have to be cut with suitable tools in the abutting edges of each of the plates, and the burr so formed is carefully beaten into the joint to make it water-tight. Considerable advantages are gained by having the butts flush-jointed, both as regards the resistance offered to the ship's passage through the water, and the development of the strength of the plating. The necessity for fitting the butt-joints closely was not formerly recognised by iron ship-builders, but now it is generally admitted; and either by planing or chipping the desired object is attained in well-built iron ships.

Butt-straps are usually of about the same thickness as the plates they connect, in some cases being $\frac{1}{16}$ of an inch thicker, in others $\frac{1}{16}$ thinner, and in others again of equal thickness with the plates. The fibre of the iron in the straps should always run in the same direction as that in the plates; so that the straps should be cut off the ends of plates. Their breadths vary with the character of the fastenings. For single riveting the total breadth of butt-strap would be from 6½ to 7 times the diameter of the rivets, for double riveting from 11 to 12 times, and for treble riveting from 17 to 18 times. In both edge and butt fastenings it is a rule to have at least a space as great as the diameter of the rivets between the edge of the plate or strap and the row of holes nearest to it; and when there are two or more rows of rivets, the practice is to allow a distance varying from 1¼ to 1½ times diameter between adjacent rows.

FISH CULTURE.—IX.

By Greville Fennell.

DISTINCTIVE CHARACTERISTICS OF SALMONIDÆ, ETC.

Yarrell tells us with truth that of the species of *Salmonidæ* existing in this country the characters and distinctions admit of considerable detail. Too much reliance has been placed upon colour, without resorting sufficiently to those external indications founded on organic structure which may with greater certainty be depended upon.

In the scale of the relative value of parts affording characters for distinction, the organs of digestion, respiration, and motion are admitted by systematic authors to hold high rank; and in the hope to induce sportsmen to become zoologists—so far, at least, as to enable them to determine the various species they may meet with by a reference to those external characters which are the most important—the specific distinctions in the genus *Salmo* will be illustrated by referring to the number and situation of the teeth, the form of the different parts of the gill-covers, and the size, form, and relative situation of the fins.

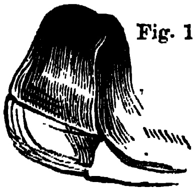


Fig. 18.

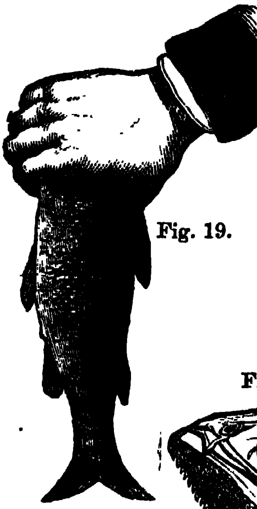


Fig. 19.

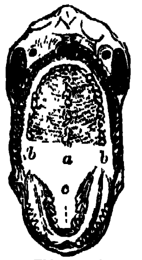


Fig. 14.

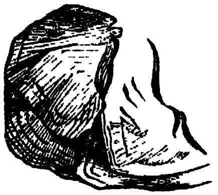


Fig. 16.

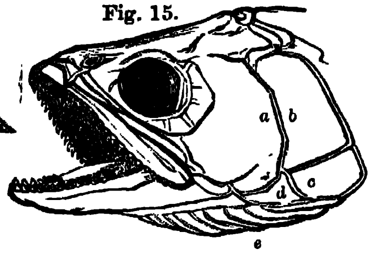


Fig. 15.

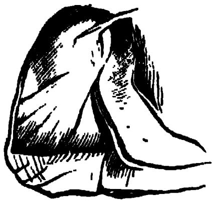


Fig. 17.

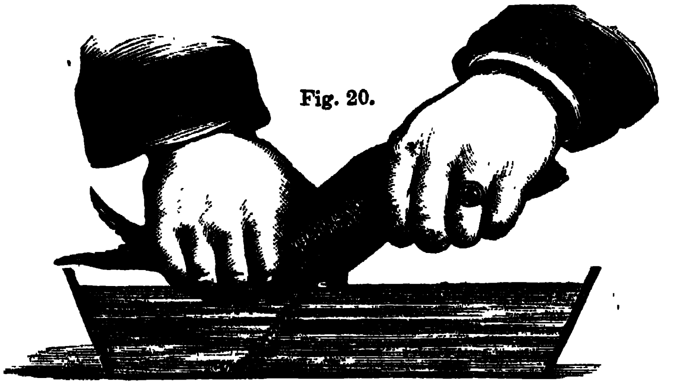


Fig. 20.

Figs. 14 and 15 here introduced represent a front view of the mouth and a side view of the head of the common trout. In the first of these illustrations (Fig. 14) *a* marks the situation of the rows of teeth that are fixed on the central bone of the roof of the mouth, called the vomer; *b*, *b* refer to the teeth on the right and left palatine bones, and the row of teeth outside each palatine bone on the upper jaw are those of the superior maxillary bones; *c* refers to the row of hooked teeth on each side of the tongue, outside of which are the lower jaw-bones. The trout is chosen, as showing the most complete series of teeth among the *Salmonidæ;* and the value of the arrangement, as instruments for seizure and prehension, arises from the interposition of the different rows, the four lines of teeth on the lower surface alternating, when the mouth is closed, with the five rows on the upper surface, those on the vomer shutting in between the two rows on the tongue, etc.

Fig. 15 represents, in outline, a side view of the head, of which *a* is the pre-operculum, *b* the operculum, *c* the sub-operculum, *d* the inter-operculum, *e* the branchiostegous rays; the four last parts together forming the movable gill-covers. The different fins are sufficiently indicated by being coupled, when referred to, with the name of the part of the body of the fish to which they are attached.

The external appearance of the adult salmon during the summer months, when it is caught in the estuaries of our large rivers, is too well known to require much description. The upper part of the head and back is dark bluish-black; the sides lighter; the belly silvery white; the dorsal, pectoral, and caudal fins dusky black; the ventral fin white on the outer side, tinged more or less with dusky on the inner surface; the anal fin white; the small soft fleshy fin on the back, without rays, called the adipose fat fin, or the second dorsal fin, is of the same colour nearly as the part of the back from which it emanates. There are mostly a few dark spots dispersed over that part of the body which is above the lateral line, and the females usually exhibit a greater number of these spots than the males.

Those colours, differing but little, are, however, in a great degree common at the same period of the year to the three species that are the most numerous, as well as the most valuable, namely, the true salmon, the bull trout, and the sea or salmon trout, which are also further distinguished from the other species of the genus *Salmo* by their seasonal habit of moving from the pure fresh water to the brackish water, and thence to the sea, and back to the fresh water again at particular periods of the year. Further specific distinctions are therefore necessary, and those that will be pointed out as existing constantly in these species will, it is hoped, enable observers to identify not only each of these, but also the other species of the genus at any age or season.

The three illustrations on the left hand—viz., Figs. 16, 17, and 18—represent the form of the different parts of the gill-cover in the three species we have just named. Of these Fig. 16 is that of the salmon, Fig. 17 is the gill-cover of the bull trout, and Fig. 18 is the gill-cover of the sea or salmon trout. The differences are immediately apparent when thus brought into comparison.

In the salmon the posterior free edge of the gill-cover, as shown in Fig. 16, forms part of a circle; the lower margin of the sub-operculum is a line directed obliquely upwards and backwards; the line of the union of the sub-operculum with the operculum is also oblique, and parallel with the lower margin of the sub-operculum; the inter-operculum is narrow vertically, and its union with the operculum is considerably above the line of the junction between the sub-operculum and the operculum. The teeth of the salmon are short, stout, pointed and recurved. As stated in the generic characters, they occupy five situations at the top of the mouth—that is, a line of teeth on each side of the upper jaw, a line on each palatine bone, with a few only on the vomer between the palatine bone; the teeth on the vomer seldom exceeding two in number, sometimes only one, and that placed at the most anterior part. There are teeth extending along the vomer, as in the salmon trout, and more particularly so in some of those trout that do not migrate.

The inner surface of the pectoral fin is in part dusky; the tail being very much forked when young; but the central caudal rays growing up, the tail is much less forked the second year, and by the fourth year it has become nearly or quite square at the end.

It may be remarked here that, looking at the form of the three gill-covers, it will be obvious that a line drawn from the front teeth of the upper jaw to the longest backward projecting portion of the gill-cover in either species will occupy a different situation in respect to the eye; that the line will fall nearest the centre of the eye in the first, that of the salmon, and farther below it in the second, that of the bull trout.

The importance of these distinctions will be readily granted by the British reader, but far more so by the colonist, as it is now an ascertained fact that in Tasmania the flattering notion had long existed that salmon introduced from English ova were plentiful in their due season in the Derwent. This delusion has, however, recently been dispelled, the supposed salmon having been proved, after the above tests, to be trout, although trout of a very fine character. In order in future to obviate an error of this nature, Mr. Youell, to whom so much is due for the introduction of *Salmonidæ* in the Tasmanian river Derwent, and from thence to many other rivers, has caused casts to be made of the true salmon and trout, which, having been coloured from and to the life by the celebrated fish-painter, Mr. H. Leonidas Rolfe, have been forwarded to these colonies for general reference. Those, however, who would study similar casts, and much more of the greatest value, should pay a visit to the Fish Department of Mr. Frank Buckland at the Kensington Museum; and, if on a Saturday, that gentleman will cheerfully and lucidly explain a variety of circumstances in the history of fish culture which, if they do not induce the listener to follow out the pursuit in practice, will add no little to his wonder and admiration of the works of God.

Figs. 19 and 20 show the method of handling a trout of 1 to 3 lb. weight, and extracting the ova from a fish of from 3 to 5 lb. weight. We have already detailed the necessary process of manipulating a salmon of a much larger size.

We may observe that roach and dace are always heavier and fatter in those waters in which the well-known external parasite of the pike abounds. Upon one occasion our fisherman, Harry Christal, was fishing most fruitlessly for roach in the Colne at West Drayton, with the customary baits of gentles, worms, and paste, when by accident he impaled upon his hook one of these parasites, with which he was induced to fish, and caught in a short time three roach with that one specimen so accidentally captured. Hence the feasible suggestion that the entomologist and the botanist shall assist pisciculture by ascertaining the kinds of living creatures and plants on which fish thrive most, and by pointing out how they may be introduced into localities where naturally they are not found. The bottom of Loch Leven is in some places covered with a peculiar weed, sheltering various insects, chiefly crustaceæ, and small snails of various sorts; the lake also abounds in the more minute entomostraceæ. Large quantities of both are found in the stomachs of the trout. This fact induced Mr. D. Esdaile ("The Rural Dean"), when consulted as to stocking a certain water with this prized trout, insisting upon the ova being accompanied by a quantity of the weeds and small stones to which the favourite food of the fish would adhere. In this respect Mr. Esdaile exhibited a proper discretion; not so another would-be benefactor to a stream in Hampshire, who brought up at some expense many bushels of the small snail of the lakes, which, while they lasted, fed the fish, but which themselves had not a chance of propagation for the want of the plant upon which they fed and propagated.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXI.—MATTHEW BOULTON, F.R.S.

BY JAMES GRANT.

MATTHEW BOULTON, whose happy improvements in mechanics rendered many important services to his country, and whose name is intimately connected with that of James Watt and the progress of the steam-engine, was the son of Matthew Boulton, by Christian, daughter of Mr. Peers, of Chester, and was born at Birmingham on the 3rd of September, 1728. He was principally educated at the private grammar school of the Rev. Mr. Ansted, who officiated at St. John's Chapel, Deritend, and was taught drawing by Worledge, and mathematics by Cooper. When he attained manhood, we are told that "he was above the middle stature and well built; he was exceedingly disposed to encourage modest merit, and was fascinating in his manner and conversation."

In his native town, Birmingham—then consisting of little more than thirty streets, though celebrated for the manufacture of leather seven hundred years ago, and for that of coarse iron articles previous to the Revolution—he established himself as a manufacturer, and invented and brought to great perfection, about the year 1745, inlaid steel buckles, buttons, watch-chains, etc. Of those great quantities were exported to France, where they were purchased "with avidity by the English, as the offspring of *French ingenuity*."

His manufactory at Birmingham soon became inadequate to his extensive improvements and many experiments; and in the year 1762 he took a lease of Soho, near Handsworth, in the county of Stafford. Two miles distant from the city, it was at that time a barren heath, with a little eminence on the bleak summit of which stood one solitary hut, the abode of a warrener. By the year 1765, Mr. Boulton had converted this place into the site of his superb manufactory, at the expense of £9,000; and in the year 1794 he purchased the fee-simple of Soho, and much of the adjacent land.

Inspired by patriotic ambition and a desire to encourage home art and manufacture, he established at Soho a seminary for draughtsmen and modellers, seeking men who were talented, and whom he rewarded liberally. This soon led to his establishing successfully an extensive manufactory for ornaments in what is called *ormolu;* and these ornaments not only found their way into the royal apartments at Windsor and St. James's, but to those of all persons of rank and taste in most parts of Europe.

On discovering that the mill which he had erected fell infinitely short, as a force, even with the aid of several horses, of that which he required to complete the great works he had in view, he had recourse in 1767 to the steam-engine, which was yet in its infancy, and did not at first answer the expectations that had been formed of it; and yet, if we are to believe Dr. Darwin and Aikin, the idea of such a power is much older than the days of the Marquis of Worcester or of James Watt, as the former asserts that Hiero of Alexandria, who flourished a hundred years *before Christ*, had "an application of the force of steam to produce a rotative motion by the reaction of steam issuing from a sphere mounted upon an axis, through two small tubes, bent into tangents, and issuing from the opposite sides of the equatorial diameter of the sphere—the sphere being supplied with steam by a pipe communicating with a pan of boiling water, and entering at one of its poles;" while the latter in the first volume of his *Athenæum*, under the title of "Omnia," asserts that Pope Sylvester II. had clocks and organs which were worked by steam about the end of the tenth century; and M. Delescluze about thirty years ago made a discovery among the MSS. of Leonardo da Vinci, that carries a knowledge of the steam-engine back to the fifteenth century, in the design for a *steam-gun* called an architonnerre, or "an invention of Archimedes."

In 1769 James Watt, of Glasgow, as related in his memoir, had obtained a patent for improvements in the steam-engine, which induced Mr. Boulton to invite him to Soho, and also to settle there, to which he consented. In 1775 Parliament granted a prolongation of the patent for twenty-five years to the Messrs. Boulton and Watt, who, on becoming partners, established at Soho an extensive manufactory for these engines, from whence they were sent to the greatest mines, manufactories, and other works in England; and among the various applications of steam, that for coining was of considerable importance, as one engine, managed by a few boys of from twelve to fourteen years, worked a number of coining machines with greater success and exactness, than could be done by the same number of able-bodied artizans, without endangering their fingers, as the machine itself laid the blanks upon the die, perfectly concentral with it, and when struck displaced one pair to replace it by another. The coining mill, which was constructed in 1788, was greatly improved, and by the end of the century was adapted to work eight machines, each of which was capable of striking from 60 to 100 coins, of the guinea size, per minute, or equal to between 30,000 and 40,000 per hour. If such a coining mill had been erected in the Royal Mint, says Shaw in his "History of Staffordshire," it would in cases of emergency be able to coin all the bullion in the Bank of England, without the necessity, which then existed, of putting Spanish dollars and other foreign coin in circulation. At the Soho mill, the same blow which struck the face and reverse, also formed the edge, whether milled, plain, or with an inscription, as in the case of crown-pieces.

"The whole of this magnificent and expensive apparatus (says Dr. Darwin) moves with such superior excellence and cheapness of workmanship, as well as with works of such powerful machinery, as must totally prevent clandestine imitations, and in consequence (as coiners were then hanged) save many lives from the hand of the executioner. If a civic crown was given in Rome for preserving the life of one citizen, Mr. Boulton should be crowned with a garland of oak."

In 1773 the ingenious method of copying pictures in oil-colours by a mechanical process had been invented at the Soho works, under the patronage of the proprietors; and, like oleography, was brought to such perfection as to make its productions be taken in some instances for the originals. The art was brought to perfection under the management of Mr. F. Eginton, who was also celebrated as a painter on glass; as stated in our paper on James Watt (Vol. II., page 139), the art of sun-painting by daguerreotype was not unknown to Messrs. Boulton and Watt.

The former, in 1788, struck with the coining machine a gold piece of the old guinea size, as a pattern, the letters of which were indented instead of being in relief, while the head and other devices were protected from wear by a flat border; and from the perfect rotundity of form, etc., with the aid of a steel gauge, it could with ease and certainty, by its specific gravity, be distinguished from any base metal. And previous to Messrs. Boulton and Watt's engagement to supply Government with copper coins, in order to bring their apparatus to greater perfection, they had exercised it in coining silver for Sierra Leone and the African Company, and copper for Bermuda and the East India Company

Many of the beautiful medals presented, about that time, to distinguished officers in both services, were from time to time struck at the Soho works.

On the accession of the Russian Emperor Paul I., Mr. Boulton presented him with some of the most interesting articles of their manufacture, and in return, received—from that unfortunate monarch, who perished by violence—a letter of thanks and approbation, together with a splendid collection of medals, specimens of all the modern money of Russia, and of many minerals from Siberia. Among the medals was a massive golden one, bearing the head of Paul. This piece, the beauty of which is said to have been unrivalled, was struck from a die engraved for the then Empress, who from her youth had taken a great delight in the arts, particularly that of engraving on steel.

With a view to still further improving and facilitating the construction of steam-engines, Boulton and Watt, in conjunction with their sons, established a foundry at Smethwick, a village in Staffordshire, three miles from Birmingham, and intersected by the canal. There the powerful agent, which had already done so much, was employed to reproduce and multiply itself; and the engines, which were there fabricated with wonderful regularity, neatness, and expedition, were forwarded to all parts of the kingdom by the Birmingham Canal, which, by means of a wet dock, communicated with the foundry.

Thus, in a national point of view, the undertakings of Matthew Boulton were in an eminent degree highly valuable and important. By collecting around him draughtsmen and artists of various descriptions, rival talents were stimulated or called into existence, and successive competition multiplied to an extent greatly beneficial to the public; while that which before had been a barren heath was covered with objects of industry, with population and plenty. The Soho works alone covered many acres, and by the time the patent expired, and Watt withdrew from them, with an ample fortune, they afforded employment for more than 6,000 persons.

Prior to this the firm had become involved in a quarrel with the famous inventor of the patent lock, Joseph Bramah, whose irritation broke out fiercely in the evidence given by him in the case of Boulton and Watt *versus* Hornblower and Maberly, which was tried in December, 1796; and on being silenced by the judge, Bramah revenged himself in a pamphlet entitled "A Letter to the Right Hon. Sir James Eyre, Lord Chief Justice of the Common Pleas," etc.

In 1809 the apparatus for *first* supplying the city of Glasgow with gas—then a wonder of the age—was prepared by Boulton and Watt, and fitted at Anderston, a suburb one mile distant from the city cross; and the whole, we are told in a print of the time, "constitutes a very pleasing exhibition. Two iron retorts of a semi-cylindrical form, each capable of containing one cwt. of coal, yield at every charge 750 cubic feet of gas, which, after being washed so as to deprive it of any disagreeable smell, is conducted into a large cubical plate-iron gasometer, of a capacity equal to 1,120 feet. The gas evolved by the regular process of carbonisation, during the day, is herein stored up for use. From this magazine, which floats in a water cistern, a main-pipe issues, which afterwards branches into innumerable ramifications, some of them extending several hundred feet under ground; thence to emerge, diffusing over a multitude of apartments a kind of artificial day, so vivid is the illumination. The flame, however, though exceedingly bright, is very soft and steady, and free from that dazzling glare which has been so greatly complained of in the otherwise beautiful light of the argand lamps." Such was the simple account of this new mode of illumination, which brought the peasantry in from the Campsie Hills and the Renfrew villages, to throng the streets, and gaze at as a new marvel, and which even Sir Walter Scott had ridiculed as a wild idea of lighting cities with smoke!

"No trouble attends this beautiful illumination," adds the memoir read before the Philosophical Society of Glasgow in 1810; "the occasional attendance of one man in the gas-house to charge the retorts and mend the fire being all that is necessary; *and no trimming or snuffing are required.*"

No expense had been spared to render his own works handsome and uniform in architecture, as well as neat and commodious; and the taste with which Mr. Boulton adorned the gardens and laid out the pleasure-grounds, rendered his residence at Soho both pleasant and picturesque; and there he died in the year 1809. He was not only a member of the Royal Societies of London and Edinburgh, but likewise of that which bears the title of the Free and Economical at St. Petersburg, and of many other foreign scientific institutions.

"To comment upon the private character of a gentleman in Mr. Boulton's situation (says the *Scots Magazine*, for the year subsequent to his death) would be a useless task: we shall therefore only observe that, as his great and expanded mind formed and brought to perfection the wonderful works he produced, so he felt no greater felicity than that of diffusing happiness around him. For a long time previous to his decease he had been confined to his room by illness, and his dissolution daily expected. His memory will ever remain dear to the British nation, whose glory was advanced in proportion to his own fame. While we commemorate those great men who have sought their country's honour in the fields of war, we ought not to omit paying a just tribute to those who have promoted arts, industry, and commerce, and diffused plenty and comfort throughout the realm, by cultivating science and applying it to the arts of peace."

Playfair, in speaking of Mr. Boulton, describes him as "a man of address, delighting in society, active, and mixing with people of all ranks with great freedom and without ceremony." James Watt also spoke of his partner in the highest terms, ascribing to his friendly encouragement, his partiality for scientific improvements, and his ready application of them to the purposes of art, his intimate knowledge of business and manufactures, his extended views and liberal spirit, most of the success that attended his own exertions.

THE LATHE.—IX.

By Henry Northcott.

SLIDE-REST APPLIED TO SIMPLE LATHE—SMALL FOOT-LATHE.

Fig. 28 shows the application of another form of the slide-rest to a simple lathe. This slide-rest has a surface-slide next the lathe-bed, and the slide and centre line of bed are kept at right angles, so that with the driving head-stock in its usual position, the motion of the surface-slide will always tend to produce a plane surface upon the face-plate of the lathe.

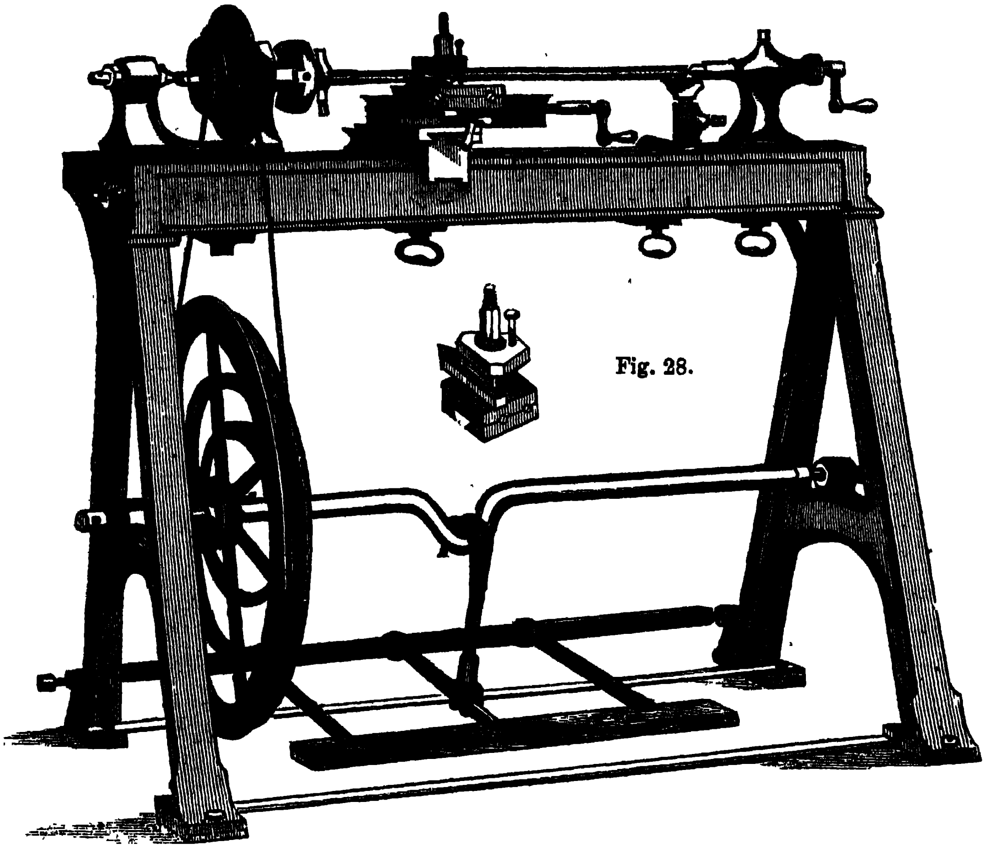


Fig. 28.

The traverse-slide is placed upon the surface-slide with the usual angular motion between the two. The traverse-slide, it will be observed, has a long motion, and this is a very desirable feature in all slide-rests applied to hand-lathes, as a good length of cut can be taken with one setting of the slide-rest; whereas if the slide be short, as is too generally the case, it becomes necessary, when turning up a long shaft, to frequently move the slide-rest along the lathe-bed into a new position. In slide-lathes or lathes in which the rest itself is moved along the lathe-bed to form the traverse-slide, it is quite unnecessary to have a long traverse-slide upon the rest; and, indeed, a long slide would be rather an incumbrance than otherwise. It must not be forgotten, in constructing or choosing a slide-rest, that the longer a slide projects out over the supporting-slide or lathe-bed, the stiffer and stronger it must be to resist a given depth of cut. The present example errs probably on the safe side in respect of weight of metal, but it is better to have too much metal in a slide than too little. A slide-rest, and, indeed, the whole of a lathe, has not only to be strong enough to resist fracture from the straits to which they are subjected, but every part ought to be strong enough to withstand these strains without springing or yielding in the slightest degree. This necessitates a great deal of metal, and unless the designer be very careful in placing it by correctly proportioning every part, lathes and most machine tools are caused to look unnecessarily heavy and clumsy. If the tool, from any cause, does not keep firmly in contact with its cut, the effect is most unsatisfactory and annoying. A most disagreeable noise is generally produced, and the surface of the work is found to be very rough and uneven. But want of metal is not the only cause of unsteadiness in a slide-rest. No quantity of iron will produce a good slide-rest unless the fit of the various sliding parts be everywhere close, and the workmanship of every part accurate. A great deal also depends upon the position of the tool with respect to the rest and to its cut, and as much upon the shape and condition of the cutting-edge of the tool, especially if the slide-rest be rather weak or unsteady. A good tool-holder also, as before mentioned, is very necessary; and in the rest at Fig. 28 the holder is of this quality. It is of the triangular plate variety, as in a previous example, but the working out is much more mechanical. There is the central bolt, which is very strong, and is furnished with

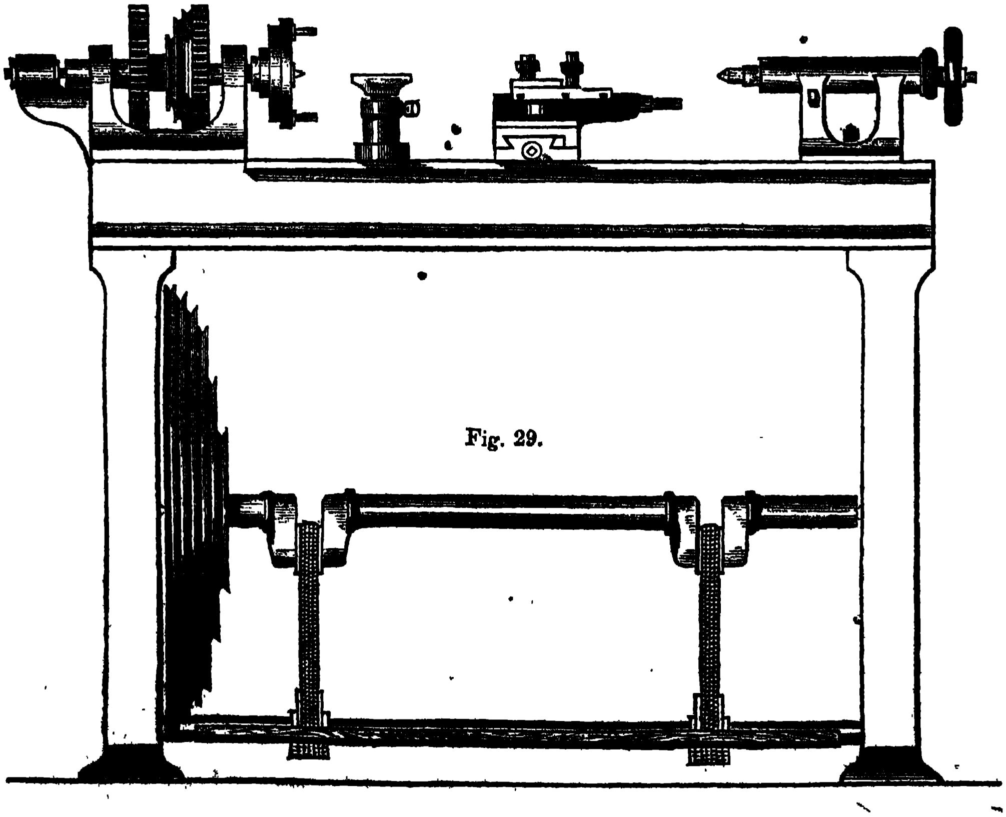


Fig. 29.

a well-fitting screw-nut. The length of the nut is unusually great as compared with the diameter, as the threads are subjected to a considerable amount of pressure and wear. The triangular plate has only one other screw through it, and this acts as a support to the third angle of the plate, and is adjustable to different thicknesses of tool, as in the previous example. At the two other corners of the plate are two knobs or projections made of hard steel, whose function it is to bear upon the tool which is placed underneath them. The two points are tightened down upon the tool by turning the nut upon the central spindle, and the tool is by this means firmly and securely held to its cut in any required position upon the tool-plate, as the triangular plate may be shifted anywhere around the central bolt. Altogether, this may be considered a fair specimen of the slide-rest as usually applied to a hand-lathe. The illustration was engraved from a photograph taken from a lathe made by Mr. Munro, of Lambeth.

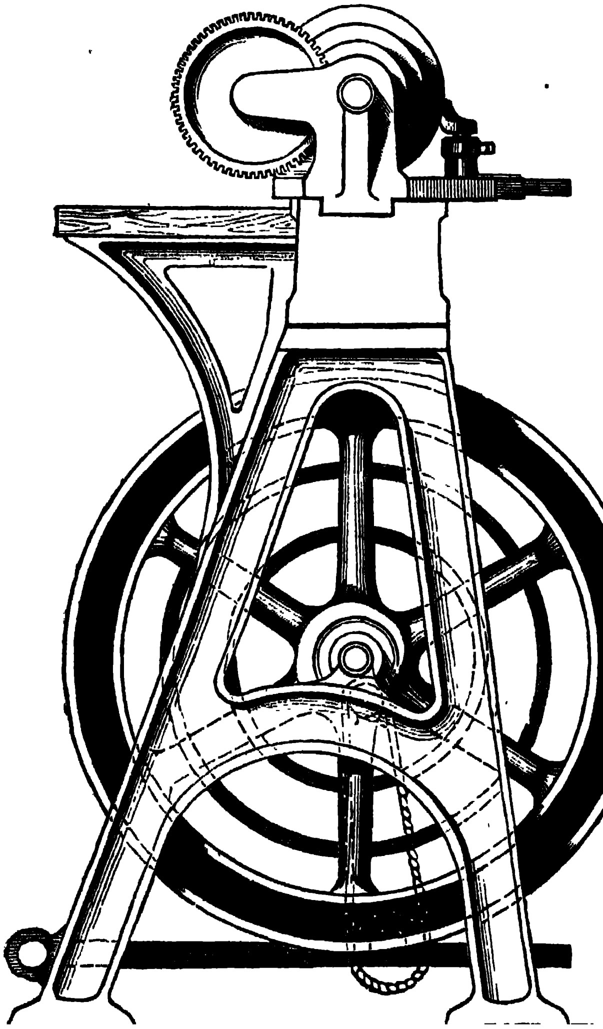


Fig. 30.

Fig. 29 is a front elevation, and Fig. 30 an end elevation of a small foot-lathe for hand-turning, but with slide-rest attached, as made by Sir Joseph Whitworth and Co., of Manchester. The lathe is driven by a treadle through two cranks, and the treadle and cranks are connected by two chains instead of the usual links. The chains pass over the crank-pins and around pulleys attached to the treadle-lever, as will be seen by the illustrations. The chains have a slow rolling movement when the treadle is in motion, and the friction is somewhat lessened by their use. Sometimes leather belts are used instead of chains; the former give perhaps a little more elasticity and a somewhat pleasanter motion when treading, but it would be difficult to say that one mode of connection has any substantial advantage over the other.

The crank-shaft is hung between centres, and the grooved cone-pulley has a set of four grooves for the fast speed and two slow-speed grooves in addition. The cone-pulley is made very heavy, so as to act as a fly-wheel, and carry the crank around against a heavy cut. The double gearing is of the usual kind, in which the wheels are slid into and out of contact with each other. The end pressure caused by screwing up the centres against work between them, and in other ways, is taken by a back-centre shown at the extreme left hand of the head-stock, and this, when practicable, is no doubt the best arrangement, as the thrust is direct, and the back-centre is easily adjusted to take off any pressure from the bearing-collars. In some cases, such as when change-wheels have to be placed upon the end of the lathe-spindle, the position of this back support becomes somewhat inconvenient, and it is sometimes expedient to receive the end thrust or back pressure upon the collars of the spindle-bearing. But in these cases the friction is certainly greater than when a proper back-centre is employed, as in the present example.

The spindle-nose carries a double or Clement's driver, and this looks rather heavy for the lathe-spindle. It may be questioned whether an ordinary driving-plate with a single arm would not do quite as well as the one shown in place, besides being considerably lighter. Both the hand tool-rest and the slide-rest are shown in position on the lathe-bed. The former is of the usual variety, as will be seen from the illustration. The slide-rest is an excellent one, and it would be difficult to find any fault either with its arrangement, proportions, or workmanship. The drawings will sufficiently explain its construction.

The screw head-stock has the internal screw and socket, the action of which has been already shown, and a sectional drawing of it given.

A bracket projects from each of the standards carrying the lathe-bed, and upon the two is placed a wooden shelf, which is very convenient for receiving the various tools, etc., that happen to be in use, and keeping them within easy reach of the operator.

Altogether, this lathe is an excellent example of a light hand-tool lathe, and the slide-rest is especially good; and in bringing our description of it to a close, it is needless to say that the workmanship of every part is first-rate.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XIII.

BY E. WYNDHAM TARN, M.A.

PLASTERING.

The work of the plasterer belongs both to the outside and the inside of buildings. When any part of the outside of a building is covered with a coating of cement or stucco, this is executed by the plasterer. The internal work of the plasterer consists in covering the walls, ceilings, and partitions with a facing of plaster, adding ornaments, mouldings, cornices, etc., as may be required. Plaster or cement floors are also executed by this workman, and also the pugging on the sound-boarding which the carpenter has laid between the joists. White-washing or lime colouring to ceilings or walls belongs also to this trade.

For outside work or stucco there are a variety of different materials used, as well as modes of applying them. Rough casting, which is plaster sprinkled over with lime and small stones; rendering with blue lias lime mixed with sand; rendering with Roman or Portland cement, either neat or gauged with sand, plain or jointed to imitate stone. In measuring cement work, take all the surface that is coated with stucco in superficial feet, bringing into yards in the abstract; deduct all openings, state how many coats are used, and the proportion of sand to cement. Facias, pilasters, reveals, etc., are taken by the foot superficial; all mouldings are taken the girt by the running length, and the area in superficial feet entered in the bill. Arris edges, beads, quirks, 4½ in. reveals, etc., are taken by the foot-run. All mitres, blocks, brackets, consoles, pateras, ornaments, etc., are numbered. Dubbing-out with tiles, in order to get an extra thickness or projection, is measured by the foot superficial, unless for a narrow string-course, when it is taken by the run. The colouring of cement work, if not done with oil paint, is taken with the plasterer's work, by the superficial yard.

Stucco upon walls that are circular on plan is measured one and a-half times the girt by the height, and the area added to the plain work.

Panelled work is usually measured by taking the round of the panel as square arris, or moulding, describing the girt of the moulding.

No allowance is made for the scaffolding used in executing the stucco to outside walls of new buildings; but if it is done to old walls the scaffolding must be charged, when erected for the purpose of doing the work. In rendering old walls, the joints are raked out, and the walls axed, which is stated in the measurement, the work being taken as before by the superficial yard.

Cement floors are measured by the superficial yard, describing the proportions of sand and cement; but small works, such as hearths, coating cisterns, etc., are taken by the foot superficial.

In measuring the internal plastering to walls, take the round of the room by the height from floor to ceiling, if there are neither skirting grounds nor cornice, but if both, then by the height from the top of the grounds to half way up the cornice; this will be brought into superficial yards and described, rendering one coat, render and set if two coats, render float and set if three coats. Take the run of quirks to beaded angle-staffs. If, however, any part of the walls of the room is formed by a quarter partition, it must be measured separately from the brick or stone walls, and taken as lath and plaster—one, two, or three coats, as the case may be; and the same is the case if the walls are battened out for the plastering.

The ceilings are measured the length by the width from wall to wall if there is no cornice, and brought into superficial yards, as lath render one, two, or three coats. When there is a cornice, deduct its width once in each dimension, or take the area half-way across the cornice. Take the girt of the cornice by the length, and bring into superficial feet; number the mitres, ornaments, pateras, centre flowers, etc.; take the run of all continuous enrichments, and describe their girt. For very lofty rooms an extra price is charged for the use of scaffolding.

Friezes, soffits, raised or sunk panels are taken by the foot superficial, running the moulding or arris of the panels, and numbering the mitres.

Coves to cornices are measured separately from the moulding, the length by the girt, and brought into superficial feet.

Various cements are used for the internal finishings, the walls being either first rendered with common plaster, or with a rough coating of cement and sand, before the finishing coat is given. The measuring is similar to that above given for ordinary plaster, the quality of the cement work and number of coats being described. Skirting in cement, arrises, quirks to staff angle-beads, narrow mouldings, beads, enrichments, etc., are taken by the foot-run. Work in panels, pilasters, shafts, friezes, mouldings, cornices, etc., is measured by the foot superficial.

In measuring the plastering to walls that are circular on plan, take the height by one and a-half times the girt, and bring into superficial measurement, adding it to the straight work.

Whitening or colouring plasterer's work is measured by the superficial yard, describing the number of coats, and what tints are to be used. If cornices have to be in more than one tint they are taken separately, and also all enrichments that are picked out in colour. Old work, that has to be re-whitened or coloured, is described as wash, stop, claircolle, and whiten or colour, by the superficial yard.

Pugging, which is composed of coarse stuff and chopped hay, laid upon the sound-boarding between the joists of a floor, is measured by the square of 100 superficial feet, taken over the whole floor, without deducting the thickness of the timbers.

In entering plasterer's work in the dimension book, the surveyor uses various abbreviations. Thus, "R." stands for render; "R. S.," for render set; "R. F. S.," for render, float, and set; "L. P.," for lath and plaster; "L. P. S.," for lath, l set; "L. P. F. S.," for lath, plaster, float, and set; "W. S. C. W.," for wash, stop, claircolle, and whiten; "L. W.," for lime whiten; and so forth.

We shall now give a specimen of the entries of plasterer's work in the dimension book, which may serve to illustrate the foregoing rules:—

EXTERNALLY—PORTLAND CEMENT.

	25 6		Plain face on brick, Pd. cement with 3 parts washed sand, jointed.
	22 0	561 0	
4)	6 6		Deduct.
	3 0	78 0	
		483 0	
2)	10 3		Pilasters, ditto, ditto.
	1 4	27 4	
2)	22 0	44 0	Arris edges, ditto.
4)	16 6	66 0	4½ in. reveals, ditto.
4)	17 6	70 0	Architrave moulding, 3 in. girt, ditto.
	25 6		Dubbing-out with plain tiles.
	1 6	38 3	
	25 6	25 6	Chamfered edge.
	25 6		Moulded string.
	1 3	31 11	
2)	2 0		Ditto caps and bases.
	1 6	6 0	
		37 11	

No. 4 mitres to mouldg., 15 in. girt. 10 brackets, 12" × 6".
„ 8 mitres to mouldg., 3 in. girt.

	22 0		R. and rough cast on brick.
	18 0	396 0	

INTERNALLY.

2)	15 0		Pugging of coarse stuff and chopped hay, 1½ in. thick.
	12 6	375 0	
8)	4 0		R. with Portd. cement and 3 of sand to hearths.
	1 6	48 0	
	15 0		Ditto, ditto, to floors.
	10 6	157 6	
		205 6	
	52 0	52 0	Square skirtg. 7 in. wide, in Pd. cement.

PLASTERING.

	56 6		R. and S. to brick wall.
	10 0	565 0	
	10 0		Add.
	1 6	15 0	
		580 0	
3)	6 6		Ddct.
	3 6	68 3	
		511 9	
	15 0		L. P. and S. to ceiling.
	12 6	187 6	
	21 0		Ditto soffit of stairs.
	3 0	63 0	
		250 6	

	21 0	21 0	Quirk.
	56 6 10 0	565 0	R. F. and S. on brick.
	10 0 1 6	15 0	Add.
		580 0	
3)	6 6 3 6	68 3	Ddct.
		511 9	
4)	10 6	42 0	Quirk.
2)	15 0 12 6	375 0	L. P. F. and S. to ceiling.
	24 0 3 0	72 0	Add soffit of stairs.
		447 0	
	24 0	24 0	Quirk.
2)	54 0 1 6	162 0	Cornice.
	54 0	54 0	Enrichment, 6 in. w.

No. 12 mitres to 18 in. cornice.
,, 2 centre flowers, 3 ft. diamr.

3)	15 0 12 6	562 6	S. C. and W. to ceilings.
	45 0 3 0	135 0	Add soffit of stairs.
		697 6	
	54 0 1 6	81 0	S. C. and distemper 2 tints to cornice.

PARIAN CEMENT.

	56 6 10 0	565 0	Trowelled for painting.
	10 0 1 6	15 0	Add.
		580 0	
3)	6 6 3 6	68 3	Ddct.
		511 9	
4)	10 6	42 0	Quirk.
	45 0	45 0	Skirting 9 in. high, moldg. 3 in. gt.

No. 6 mitres to skirting.

2)	7 0 1 6	21 0	Pilasters.
	2 0 1 6	6 0	Plain moldg.

We have now given a specimen of entries of plasterer's work in the dimension book, first taking all parts which are to be worked in Portland cement, externally and internally; then the plasterings applied to the walls, ceilings, etc.; and, lastly, the finer work that is done in Parian cement. We have now to prepare an abstract of these dimensions, which will be found below. In this the work in cement and the work in plaster are taken separately. In the former the work in Portland cement with the addition of three parts sand is distinguished from the work in Parian cement, and is taken according to the mode of measurement by superficial area, run, or number. The work in the finer cement is also taken in the same way, but in this case it has been found more convenient to arrange the different kinds of measurement under one another instead of side by side. This has also been done with the rough casting and pugging, which is taken by superficial measurement. The same course is also adopted in dealing with the plastering, which is also arranged according to superficial area, run, and number.

ABSTRACT.

Portland Cement, with Three Parts Sand.			Parian Cement.	Plastering.			
Superf.	Run.	Number.	Superf.	Superficial.		Run.	Number.
R. on bk. jointed. ft. 9)483 0 53 yds. 6 ft.	Arris edge. ft. 44 0	Mitre to 15 in. mo. 4	Trowelld. for paintg. ft. 9)511 9 57 yds.	R. S. ft. 9)511 9 57 yds.	L. P. S. ft. 9)250 6 27¾ yds.	Quirk. ft. 21 0 42 0 21 0 87 0	Mitre to 18 in. cornice. 12
Pilasters. ft. 27 4	4½ in. reveals. ft. 66 0	Ditto 3 in. ditto. 8	Pilaster. ft. 21 0	R. F. S. ft. 9)511 9 57 yds.	L. P. F. S. ft. 9)447 0 49¾ yds.	Enrichment, 6 in. w. ft. 54 0	Centre flower, 3 ft. diam. 2
Moldd. ft. 37 11	3 in. moldg. ft. 70 0	Brackets, 12″ × 6″ 10	Moldg. ft. 6 0	S. C. W. ft. 9)697 6 77½ yds.	Cornice. ft. 162 0		
Hearths and floors. ft. 205 6	Chamfd. edge. ft. 25 6	R. Rough cast. ft. 9)396 0 44 yds.	Run. Quirk. ft. 42 0	S. C. Distr. 2 tints to cornice. ft. 81 0			
Dubbing out with plain tiles. ft. 38 3	7 in. skirting. ft. 52 0	Pugg. 1¼ in. thk. ft. 100)375 3¾ sqrs.	Skirtg. 9in. high, with 3 in. mo. ft. 45 0				
			Number. Mitre to skirtg. 6				

PRINCIPLES OF DESIGN.—XXX.

BY CHRISTOPHER DRESSER, PH.D., F.L.S., ETC.

STAINED GLASS.

FROM early times it has been customary to colour glass. To the ancient Egyptians a method of forming glass of various tints was known, and by producing a mass of glass consisting of variously coloured pieces vitreously united, and cutting this into slices, they, in a costly and laborious manner, produced a sort of stained glass which might have been employed for the sides of lanterns or other purposes. The Greeks were acquainted with a similar process, and bowls formed in this manner by them are common in our museums.

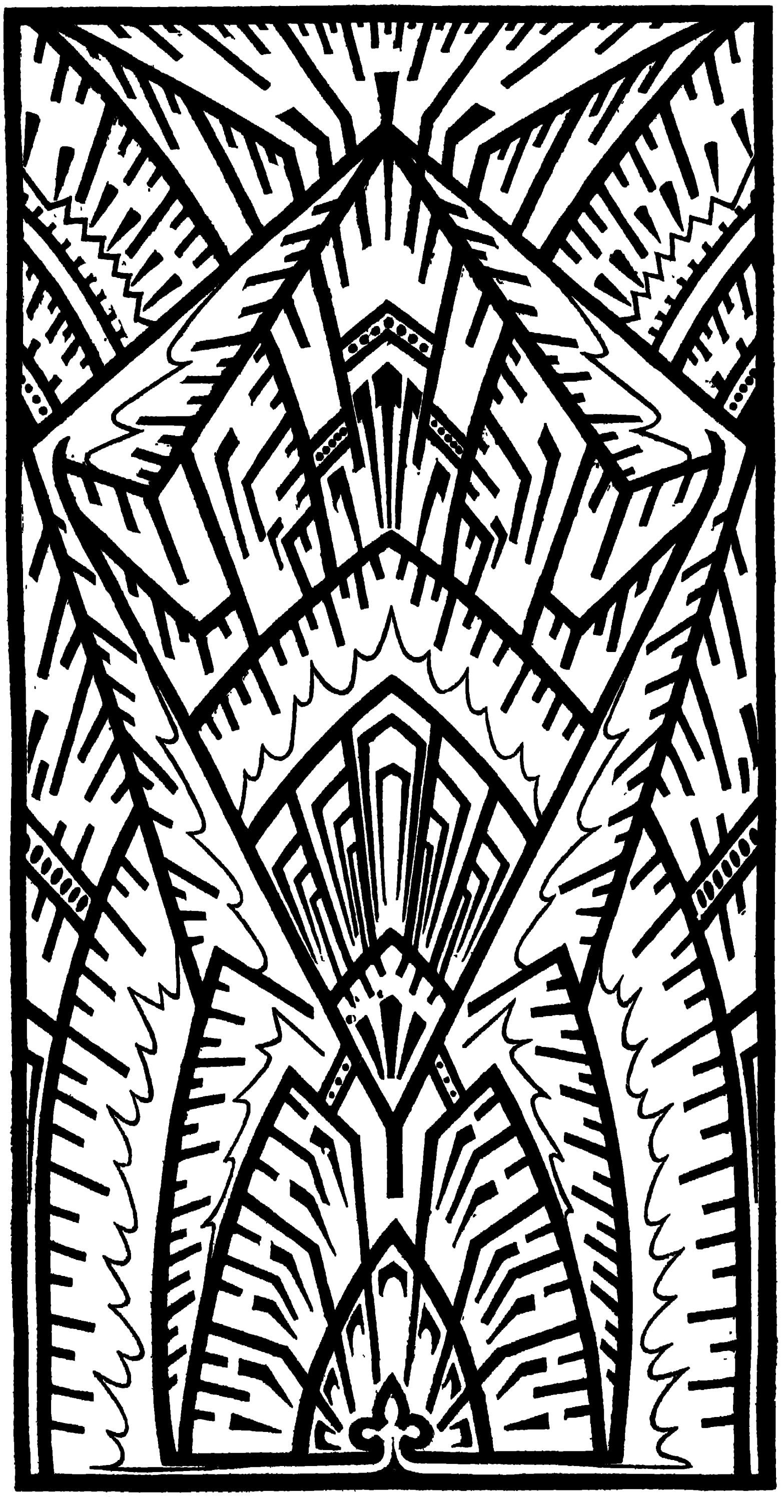


Fig. 143.—DESIGN FOR A WINDOW IN STAINED GLASS.

Soon after the re-discovery of glass in our own country, methods of colouring it were sought out, and beautiful cathedral windows were formed, which, soon after the discovery of the art of producing coloured windows, were of such beauty, and were so thoroughly fitted to answer the end of their creation, that little or no improvement upon these early works has even yet been made, and much of the decorative glass which we now produce is far inferior to these early works both as regards design, colour, and mode of treatment.

A window must fulfil two purposes—it must keep out rain, wind, and cold, and must admit light; having fulfilled these ends, it may be beautiful.

If a window commands a lovely view let it, if possible, be formed of but few sheets (if not very large, of one sheet) of plate glass; for the works of God are more worthy of contemplation, with their ever-changing beauty, than the works of man; but if the window commands only a mass of bricks and mortar inartistically arranged, let it, if possible, be formed of coloured glass having beauty of design manifested by the arrangement of its parts. A window should never appear as a picture with parts treated in light and shade. The foreshortening of the parts, and all perspective treatments, are best avoided. I do not say that the human figure, the lower animals and plants, must not be delineated upon window glass, for, on the contrary, they may be so treated as not only to be beautiful, but also to be a consistent decoration of glass; but this I do say, that many stained windows are utterly spoiled through the window being treated as a picture, and not as a protection from the weather and as a source of light.

If pictorially treated subjects are employed upon window glass, they should be treated very simply, and drawn in bold outline without shading, and the parts should be separated from each other by varying their colours. Thus, the flesh of a figure may be formed of glass having a pink tone; the robe of glass which is green, purple, or any other colour; the flower of white glass; the leaves of green glass; and the sky background of blue glass. All the parts will thus be distinguished from each other by colour, and the distinction of part from part will be further enhanced by the strong black outline which bounds the parts and furnishes the drawing of the picture.

Strong colours should rarely be used in windows, as they retard the admission of light. Light is essential to our well-being; our health of body depends in a large measure upon the amount of light which falls upon the skin. Those wonderful chemical changes, in the absence of which there can be no life, in part, at least, depend upon the exposure of our bodies to light; let our windows, then, admit these life-giving rays. It must also be remembered that if light is not freely admitted to an apartment the colours of all the objects which it contains, and of its own decorations if it has any, are sacrificed, for in the absence of light there is no colour.

It is not necessary, in order to the production of a beautiful window, that much strong colour be used; tints of creamy yellow, pale amber, light tints of tertiary blue, blue-grey, olive, russet, and other sombre or delicate hues, if enlivened with small portions of ruby or other full colours, produce the most charming effects, and by their use we have consistent windows.

A good domestic window is often produced by armorial bearings in colour being placed on geometrically arranged tesseræ of slightly tinted glass. In some cases such an arrangement as this is highly desirable, for the room may thus get the benefit which a bit of colour will sometimes afford, and at the same time a pleasant view may be had through the uncoloured portion of the window. As an illustration of this class of window, we extract one from the catalogue of those excellent artists in stained glass, Messrs. Heaton, Butler, and Bayne, of Garrick Street (Fig. 145)

No architectural constructive feature should be introduced into a window—thus, an elaborate architectural canopy overshadowing a figure is not at all desirable. If a figure is formed of a perishable material, and stands on the outside of a building, it is well that it be protected from the rain by a canopy; but such a contrivance when introduced over a figure drawn on a flat window is absurd, being useless. Let us always consider what we have to do before we commence the formation of any ornamental article, and then seek to do it in the most simple, consistent, and beautiful manner.

More than once in the course of these papers I have protested in strong terms against pretence in art and art-decoration—the desire to make things appear to be made of better material or more costly substances than what they have in reality been wrought from; that leads most men to paint and varnish a plain free-stone mantelpiece in imitation of some expensive marble, or to make doors and window-shutters, skirting and panelling that the carpenter has fashioned out of red or yellow deal, assume the appearance of oak, or maple, or satinwood, by the deceptive skill of the grainer. In no case can the imitation ever approach a fair resemblance to the reality it is proposed to imitate. The coarse, rough grain of the soft free-stone, which is incapable of receiving a polish, or rather of being polished until it becomes as smooth, and even, and lustrous as good glass, can never be made by successive coatings of paint and varnish to afford a satisfactory resemblance to the marble that it is supposed to represent, however carefully the cunning hand of the painter may have imitated the veins, and spots, and curious diversities of colour with which Nature has variegated the surface of the substance that he is endeavouring to copy. Nor, again, can a coarse-grained, soft wood, however skilled may be the hand that manipulates it, be treated so as to resemble the texture and smoothness of hard, close-grained wood, which from its very nature is capable of receiving the high polish that the softer material can never take if treated by the same process. And what is applicable to the treatment of wood and stone is applicable also to the treatment of glass: for as a free-stone mantelpiece or deal door, however suitable and pleasing to the eye either may be when simply painted in the one case and varnished in the other to preserve the surface from the deteriorating influences of dirt of any kind, can never be made by the exercise of the highest skill to present the appearance of marble or oak; so glass, by the application of colour rendered transparent by varnish, can never be brought to resemble glass stained or painted by the legitimate method, either in delicacy of tint, or depth, and richness, and brilliancy of deeper colour. The greater part of the imitative stained glass, or "diaphanie," as it is styled, fails not only in colour, but in design; and in this indeed it may perhaps be said to be chiefly faulty. The designs for the most part which are printed on paper in colours err principally in being too elaborate, and in representing figures and scenery which are not in character or keeping with the designs that are usually represented in painted glass. If confined to simple diaper work, or borderings and heraldic emblems, as shown in Figs. 144 and 145, or patterns similar to that shown in Fig. 143, the artistic effect produced would be more satisfactory, although it can never equal genuine stained glass in depth of colour or purity of tone. But there is no necessity for any one who is averse to doing so to resort to imitation even in a means of decoration apparently so far beyond the reach of most of us as painted glass. The material, in the first place, is cheap, and the mode of procedure has been described in some of the papers that appear in this work under the general title of "Practical Application of the Fine Arts." It may be urged by many that a want of skill or an inability to draw may present an obstacle to success. It may do so for a time; but a will to succeed at last, aided by patience and perseverance, will ultimately overcome all obstacles.

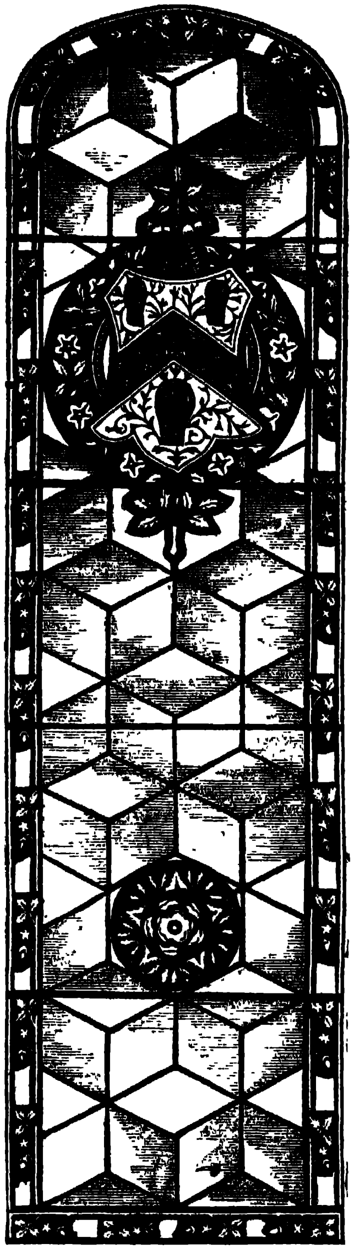


Fig. 145.—WINDOW WITH SHIELD, ETC.

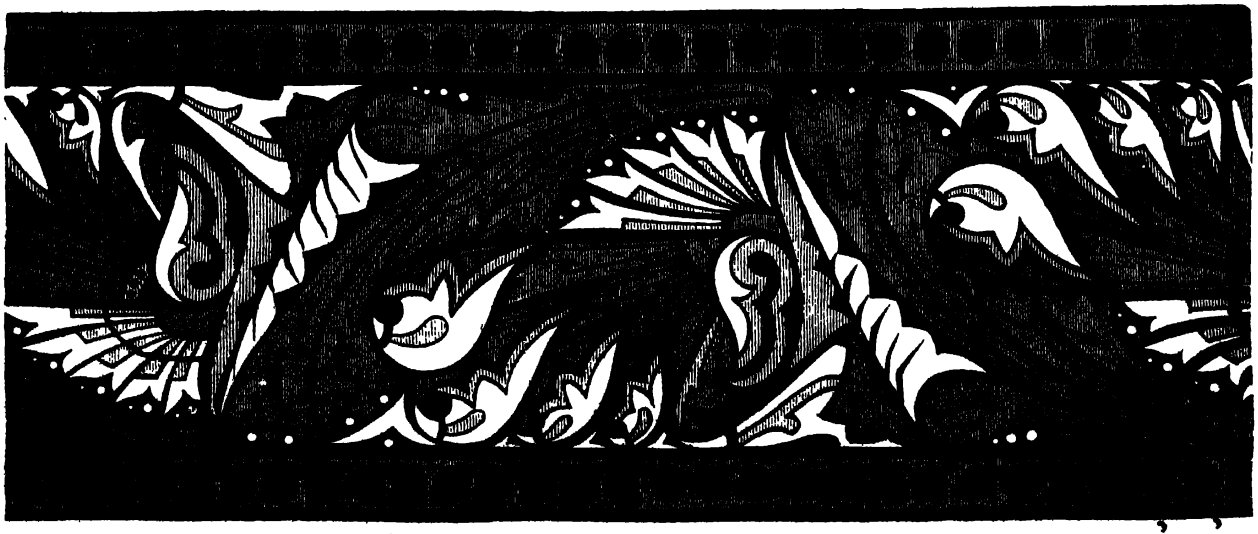


Fig. 144.—WINDOW-BORDER IN STAINED GLASS.

SOLDIERING.—V.

BY A STAFF OFFICER.

ARMAMENT: CAVALRY.

WHILST immense improvements have been gradually introduced into the equipment of other arms of the service, hardly anything has occurred to render the action of cavalry on a battle-field more effective than it was formerly. Now, as formerly, the power of cavalry in actual attack depends on the extent to which the velocity and weight of the horse is brought into play. It follows at once that the weapons which are most suitable in attack, are those which give fullest effect to these. Little improvement has been introduced into the hand-to-hand weapons of war—the sword and the lance. On the other hand, since men on horseback can only use fire-arms with less, not with more efficiency than men on foot, improvements in them tend scarcely to increase the power of cavalry.

The result, however, is not to render the action of cavalry less important, but to change its character. There are still cases, as the fight at Rezonville in the last war has taught us, in which even now vast masses of cavalry may, by devoted courage, so hamper and delay the action of an enemy as to save an army. But the cavalry is almost inevitably destroyed. A general has still sometimes to call upon his horsemen to make the sacrifice, but it is like asking men to lead a forlorn hope. Victory may result. Few of those who have prepared for it will live to see it. The great problem, however, under ordinary circumstances, is how to get with the least sacrifice the greatest amount of value out of an arm which a very brief consideration of the facts will show to be even more essential than formerly to the safety and success of an army.

The tremendous power of modern weapons has rendered the element of *time* one of even more absolutely vital consequence than it was formerly. For within a given time, a properly prepared army may inflict upon an army unprepared a disaster far more complete and final than was ever possible formerly. Hence to obtain the fullest information at the earliest possible moment has become not merely an *important* matter, but one of altogether paramount importance. Now time is the very element in which cavalry has always had the advantage over all other arms of the service.

Nor is that all. The suddenness of the effects of modern fire-arms has produced a tendency to as sudden discouragement even among the best of troops. Gravelotte supplies us with a notable instance of it, even among those who had been victorious in every fight. Such panics, if troops are fit to fight under modern conditions at all, pass away almost as rapidly as they occur. If an enemy observe them, and taking advantage of the favourable moment act upon it, victory is in his hands; if he allows the chance once to pass away, his hope of its returning is small. Now, here again time being the element of all importance, cavalry is the arm to be used. Moreover, the effect of cavalry has always been essentially moral. Nothing impresses the imagination so much as the apparent power of clouds of horsemen pouring down upon the seemingly devoted heads of the pigmy-looking foot-soldiers who are crouching in the ground to take aim at them. It needs only that the infantry man now-a-days should be calm, and should realise the efficiency of his weapon, in order to render the attack, powerful as it is in appearance, impotent in practice. But men in panic are not calm, do not reason. Hence cavalry thrown at the right moment upon discouraged and somewhat disordered infantry, ought to render it impossible for them again to take part in the action then going on.

Furthermore, since an army once beaten is greatly discouraged, great opportunities are sure to present themselves after a battle, and towards its close. What I spoke of in the last paragraph are rather incidents in the course of an action. Whole armies are rarely so disorganised at once by a single panic, that they may be freely assailed in the way there spoken of whilst a battle is in full vigour. A brigade or a battalion, under exceptionably severe stress of fighting, exposes itself to such assaults, it may be at a very early stage of the fight. These incidents, whenever they occur, must be taken advantage of. But after a lost battle, or towards the end of the day when it is becoming clear that the battle will be lost, the whole of the beaten army, without being panic-struck, tends to yield to a sense of despondency. Troops that have been comparatively little engaged feel this almost as much as those that have been hotly pressed, provided the fresher troops have been able to realise the extent of the disaster, and unless they are exceptionally war-tried men. Here again, therefore, immense opportunities, now as formerly, present themselves to the arm which strikes most rapidly, and which most impresses the imagination. The effect produced by cavalry acting in this way is in reality *far greater* than formerly; for while men cowed by disaster are not much more deadly enemies if they have breech-loaders in their hands than if they had the Brown Besses of the Peninsula, let them once recover themselves, and each man represents a far greater power to be overcome than in the old time. It is, therefore, more important than ever to strike whilst the task is relatively easy. On the other hand, a much smaller body of infantry, if it retain order and remain uncowed by disaster, will now be able to repel the incursions of pursuing cavalry.

Once more, since cavalry will be used on both sides, and when one body of horsemen is thrown in to take advantage of panic or disorder, another will be launched to save the assailed infantry from disaster, it becomes of the utmost importance to have in hand a body of horsemen so armed and equipped as to be able to overcome any whom the enemy may bring into the field.

I have pointed out as I proceeded through the above enumeration of the chief purposes for which cavalry is required, how far the conditions apply at the present moment; but the distinctions between the different classes of cavalry to meet these necessities have sprung up in the past, and have in the main differed little, except perhaps in the relative degrees of their importance, from those which we now possess, or indeed now require.

The first broad distinction in the classes of cavalry employed is that between "heavy" and "light:" the former, intended to consist of such powerful men and horses, that it shall be able to ride down all opposition, and to be so equipped as to be victorious in onsets of cavalry against cavalry; the latter, intended to develop to the full all qualities of rapidity and prompt action. We have also what are known as "medium" cavalry, intended to do much the same work as the light, but to be also a supporting body for them in the shock of battle.

The light cavalry is especially designed to fulfil all those duties of gathering information, watching round the outskirts of an army, foraging, striking short rapid blows against disorganised troops, to which I have already alluded as of so much importance, and which were popularly attributed to the Prussian Uhlans or lancers during the recent campaign. In Prussia, however, the Uhlans are medium, not light cavalry, and for many of the duties of this kind they are the least fitted of all, except the very heavy cavalry. During the late war it became important to throw as large bodies of cavalry as could be gathered together round the advancing armies, and hence as in open country lancers were very effective, and little actual fighting was required, they, as well as others, were pushed forward far in advance of the army. The lance has been rightly called the queen of cavalry weapons, for it is the one which gives to the horseman the fullest play in those respects in which he has advantage over the man on foot. Its effect is produced by the actual forward dash of horse and horseman; the very nature of the blow which it delivers protects its holder. For the horseman, even the sword is most effective when it is used as a rapier, not when it is raised to strike a blow. For the rapier thrust gains force from the horse's impulsion; the sword cut gains nothing from that cause, and in the delivery lays open the swordsman: hence the advantage of a weapon which, depending solely on its thrust, has for it the longest possible reach. The lance is, however, far more valuable for large bodies of horsemen acting together, than for mere scattered advanced parties; it is awkward and fatiguing for very light work. For these purposes the hussar is the prince of horsemen. The armament of hussars with us is the sword and breech-loading carbine, with no defensive armour. The lancer has sword and pistol besides his lance, with no defensive armour.

But whether for outpost duty—that is, for the watch and ward over an army, and collecting information—or for the battle-field, light cavalry of whatever kind require to be supported. Experience in the past has been fully corroborated by recent evidence, as to the fact that the support which they require is of two distinct kinds. For battle fighting, where cavalry attack will be met by cavalry counter-attack, the best of all support is that furnished by powerful cuirassed regiments, equipped with armour genuinely defensive against cavalry weapons, who by sheer weight and impetus, as has been proved again and again, can, if properly handled, be almost certain to ride down the best of light horsemen. The light horsemen may catch them at a fault; but when the two fairly meet, the lightly equipped soldier specially prepared for other work has hardly a chance against his powerful and well-protected enemy. On the other hand, these cuirassed regiments require to be kept in reserve specially for these duties; to employ them in the harrying light work of a campaign is to destroy them. For this purpose another kind of support requires to be furnished. The name "dragoon" has become a most indefinite one with us, implying little else than a heavy cavalry soldier. In its origin, in its earlier use, as understood by Napoleon and during the American War of Independence, it had a very different meaning. The latest experience of the war of 1870 convinced all who passed through it that the old dragoon must be revived. His essential character was that of a mounted rifleman: his pride to be so effective on foot that the enemy were certain to mistake him for the best of infantry soldiers, and to believe that the solid infantry of the army, and therefore the guns were arriving, so that it was time to abandon any weakly held outpost. Rossel has recorded how often villages which otherwise would have been hotly contested for hours, have fallen at once before such trained dragoons, because of the false impression they created that greater force was at hand. But to gain this the dragoon must be in all respects equipped and trained as an infantry soldier; taught to ride well, only that his transference from point to point may be as rapid as possible. His drill must be identical not with that of cavalry but with that of infantry when he is on foot; every part of his equipment must tend to make him put confidence not in the force of his horse in a charge, but in the efficiency of his weapon when he is dismounted: such ought to be the real characteristics of this most invaluable of soldiers. We do not at present, except in the Hampshire Yeomanry, possess a specimen of him; his creation has been invariably advised by all who have considered the question how to bring the gain of time which the horse offers into such combination with our all-efficient fire-arms as shall enable us to seize positions by virtue of the horse's rapidity, and to hold them by virtue of the power of the new arms. The difficulty that has always stood in the way is the dread lest we should only create bad infantry and bad cavalry: we are sure to produce that result as long as the only test we apply as to efficiency is that of parade. Dragoons will constantly tend more and more to be mere heavy cavalry; but in proportion as our training in peace time becomes more and more a study of analogous duties in war, in that proportion will an appreciation of the importance of the mounted rifleman or dragoon be extended. Men will take a pride in belonging to a body which has more opportunities for dealing startling blows that tell throughout a whole campaign than, in proportion to numbers, any other part of an army whatever. During the fighting in the Le Mans campaign the Prussian cavalry, to save the weary infantry, took duty all round the resting army. Many were the fights which occurred in that enclosed England-like country between the Prussian dismounted horsemen and the French levies; the result was that before long all became convinced that as such duties must often now fall to the lot of cavalry, it was essential to place in their hands a good far-reaching fire-arm. Hitherto the Prussians had had a most legitimate fear lest if the fire-arm were made too good, the cavalry should begin to trust to it when mounted rather than to the impulse of the charge. The result would inevitably be that the horseman, using his fire-arm under circumstances of less advantage than the foot-soldier, would be beaten in every encounter. But the days are past when we could afford to deprive ourselves of an important advantage, lest our men should make a wrong use of it. We must meet the difficulty by superior training, not by defective armament. This, however, we shall have to consider later. At present it is sufficient once more to press the fact that whatever fire-arms may be given to cavalry, they are essentially either for use on foot, in exceptional instances for cavalry encounters, or for isolated foraging. For the assault of broken infantry and all such purposes the less they are used the better. The only distinction in our service among the heavy cavalry is, that the household cavalry are armed with cuirass, steel helmet, sword, pistol, and breech-loading carbines. The "Heavies" are armed with brass helmets, swords, and breech-loading carbines. The Scots Greys alone are equipped so as to look like mounted guardsmen. It may be safely predicted that one of the earliest results of the first war we are engaged in will be the creation of a corps of mounted riflemen. Unfortunately, creations of corps during war time are not easy now-a-days.

EQUIPMENT: CLOTHING.

We pass now to the consideration of those other matters of equipment scarcely less necessary to be noted even than armament itself. First of all, clothing; and, secondly, the few essentials which require to be carried on the persons of the foot-soldiers, and on the horses and carriages of the cavalry and artillery.

As to clothing: some means of distinguishing between the civil population and those engaged in fighting was felt to be needed as soon as war began to be conducted in a civilised manner. The importance, for the sake of the civil populations themselves, of insisting that none shall fight who do not wear the uniform of one of the armies engaged, has been pointed out again and again by those historians who have most carefully examined the question. Nevertheless, it almost always happens that during a period of war patriotic and personal excitement drives the peasantry of an invaded country into acts of individual hostility against the enemy. The duty of the government of a country so invaded is to publish at once the clearest possible information to the people of the invaded districts, telling them by what sacrifices they can best aid the general effort to repel the invaders. The aid which true patriotism would offer is an entire submission to directions so issued. The great difficulty usually lies in this, that the mass of a large population does not realise what an invasion is till the hostile armies have shown themselves and committed acts asserting the right of the strong. Then furious wrath produces terrible acts, followed by more terrible reprisals. Hard as it may seem, it has been powerfully argued that the wisest and most humane course, where a whole population has not been able to fly before an enemy, and where the war is one between civilised nations, is to leave none but women and children, the aged and infirm, in the villages through which the invasion passes, and to sweep the whole virile population of those provinces into the service of the army. The population thus left should offer no resistance whatever to the enemy. No modern general dares to allow atrocities to be committed where no resistance has been offered. His difficulties will be too seriously increased by any such conduct. But what is for him an inconvenience, is for the peasantry decimation, if not destruction; for, preach as we may, no army will allow itself to be quietly murdered off one by one by men whom it has had in its power, and has spared on the understanding that as they do not wear the uniform which proclaims their hostility they will not act overtly against it.

The Prussians, economical as they are, meet the difficulty by having *his suit of uniform ready*, and his appointed place assigned to almost every man in the whole country who is capable of actively aiding their own army in any capacity. It is no doubt not necessary for us to take the precautions which are indispensable to nations unprotected by our strip of blue water, but the illustration is sufficient to show how very important a national question uniform may become. To the army it is the outward sign of its unity and of its common duty. If, therefore, the proposition from which I have started is true—that the question to be considered in each matter is how the spirit you desire can best be developed—it is scarcely possible to doubt that men should be taught to have a great respect for their uniform.

As all things which are necessary and good in themselves have a disagreeable part, so this is apt to present itself often to outsiders under a very unpleasing aspect. Foolish men in every profession and calling do not see the difference between a happy confidence that the work they have chosen is for them the best of all work, and a contempt for the work on which others are engaged. Foolish men outside every profession and calling mistake the pride which the best men will always have in their own business for personal egotism and conceit. The two react much on one another, and hence it very often happens that it is regarded as a special offence of the army against the nation, that men are taught to hold up their heads proudly, and to walk along "as if everything they saw belonged to them." It is a misfortune that such mistakes as to the meaning of pride in a calling should be made on both sides. It is, no doubt, a misfortune that we are not in the millennium; when we are, it may be presumed that armies will cease to exist. But in the meantime, those who wish to have an army effective must be content to endure the sight of a certain amount of so-called "military swagger." If it is not accompanied by a certain special readiness to assist others, and to fit into awkward positions, it may be safely assumed that the man is the worse soldier on that account. To take a single instance, try whether those Life-Guardsmen who in front of the Horse-Guards offices seem to be each taking up the space of three men as they pace up and down, are when you speak to them more or less ready than the clerks in the War Office to lend you all the assistance in their power for getting the information you require.

It immediately follows from this principle of cultivating as far as possible the soldier's respect for his uniform, that his dress should be such as will tend to make him take a pride in it. A man dressed in sackloth and ashes may feel that his dress is exactly the one that he ought to wear, but it would be a contradiction in terms to say that he would take a pride in it; his object is to learn to take pride in nothing. I have often heard men say that you ought to make soldiers' clothing handsome, because handsome uniform is the bait with which to catch recruits. I do not think that is either a true or an honest way of looking at the matter. If it were a deceptive bait, I should say you did yourself more harm than good, since it is more essential to an army than to any other body to be joined by those only who heartily wish to belong to it. Moreover, as a matter of fact, those regiments which find it easiest to get good recruits, though they are largely assisted by their uniform in doing so, are certainly not those which are most gaudily dressed. The Rifle Brigade, for instance, is perhaps the most serviceably dressed of line regiments, but it is not the most showily got up. What I believe the fact to be is, that there is a certain contagiousness in any genuine feeling of pride in a good regiment; that that contagiousness is the best possible agency for recruiting; that the pride itself is to some extent fostered by a liking for their own uniform among the men of a corps, affected no doubt partly by what their civilian friends think of it.

The other matters which concern the clothing of soldiers are chiefly such as common sense would suggest; that it shall be judiciously modified according to the climate in which it is to be used; that it shall be as convenient and as durable as it can be made. There is only one point in which the conditions of a soldier's work introduce a matter of special importance; he should be able to carry certain changes of clothing with him if possible, and hence it is very advisable that his garments should be as light as other conditions will permit. Practically this is a matter so difficult to reconcile with cheapness and other requisites that it may be said to be wholly ignored.

OPTICAL INSTRUMENTS.—XXI.

BY SAMUEL HIGHLEY, F.G.S., ETC.

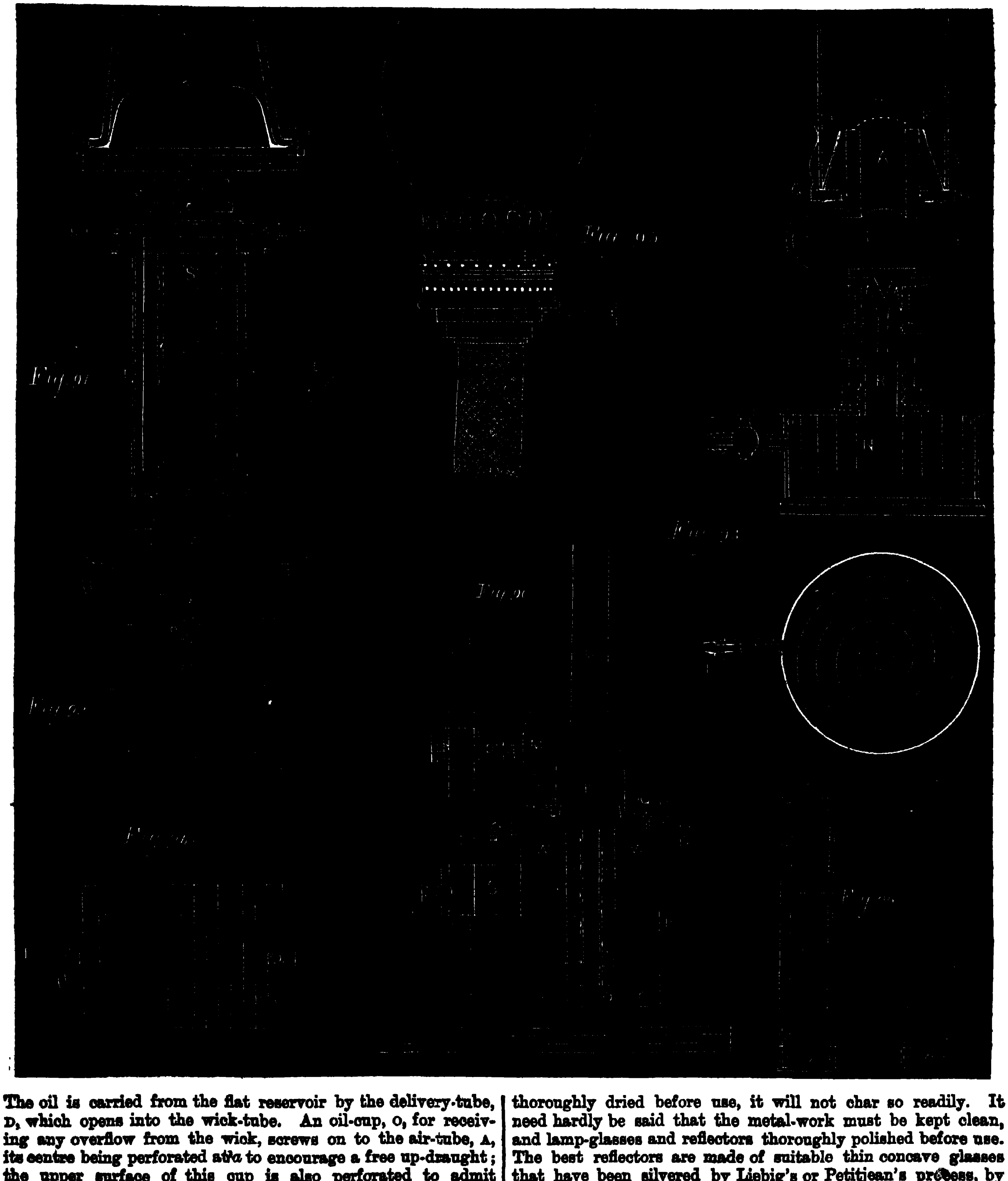
ARTIFICIAL SOURCES OF LIGHT (*continued*).

Paraffine Wax Burner.—Solid paraffine, together with the recently introduced "ozokerit," is extensively used for the manufacture of candles. For such purpose, the most purified samples possessing a high melting-point are those most suitable, *hardness* being the quality most essential for candle-making. The crude sample, having the lowest melting-point, may be burnt in a suitable argand lamp, if reduced to a melted condition, and presents some advantages to those who object to the oily nature and odour of paraffine oil and petroleum, as paraffine wax is clean to the touch and perfectly odourless, while it burns with a pure white light that is alike intense and dense in the flame, and is *perfectly free* from danger, for, if spilt or overturned, it immediately solidifies, and may then be peeled off anything it settles on. The drawback to its use is that a of it, takes a long time to melt, which is inconvenient. The lamp suitable for burning melted paraffine wax is shown in Fig. 90. It consists of a cylindrical reservoir, R, of stout brass, 3¼ inches high and 2¾ inches diameter, with a thick brass central air-tube, the stoutness of material being necessary to keep the mass of paraffine liquid when once thoroughly melted by the heat conveyed from the flame through the metal-work to the centre of the reservoir.

The wick is fitted to a little ring of brass, from which projects a pin that runs in a serpentine groove cut on the inner side of the air-tube, and drops into a slot cut in a tube, W, placed outside the wick concentric with the air-tube. From the top of this slotted tube a broad flange extends to the outer cylinder of the reservoir, by which the wick-tube is kept in place, and acts as a guide when it is rotated by a stout pin, P, riveted on the upper side of the guide-flange. By this pin the wick can be wound down to the bottom of the reservoir, and the wick can then be cut off even with the top of the central air-tube. Over the top of the cylinder a brass cap fits that carries an oxygenating cone, K, and a screw-gallery, G, that supports the chimney, C. In this cap a hole is cut that fits over the pin, P, so that when it is rotated on the cylinder by means of three ebony balls, B, fixed to its circumference, it likewise rotates the flange connected with the wick-tube, and allows of the wick being raised or depressed to the proper height for perfect combustion. If the height of the chimney has been properly adjusted to this kind of lamp, a short bright flame should be obtained that is perfectly free from smoke; should it smoke, a longer chimney is required. Should the flame be thin, the chimney is too long; if drawn in, the chimney is too long or too much contracted. In this arrangement the wick is somewhat disposed to char. It would be a great improvement if wicks could be made of asbestos. In spirit-lamps I have found that a wick may be made of fine wire (platinum is preferable, though the most expensive) fitted very tight into the wick-holder, when the spirit may be sucked to the summit through the interspaces by capillary attraction; but such an arrangement is not suited for non-mobile liquids, like vegetable oils or melted wax, that moreover tend to clog any such contrivance.

The wax may be melted by cutting it into shreds before filling the reservoir, from which the wick and other parts have been removed, and placing the lamp on the hob, or in an oven; but the better plan is to raise the lamp on the supporting-rod by the adjusting-tube, T, and placing beneath the central air-tube a small flat capped spirit-lamp. The adjusting-tube is attached to the reservoir by a block of wood, S, that serves as a convenient handle when the lamp is hot. The mirror, M, is arranged and adjusted on the sliding tube, T, in the manner previously described.

Animal Oil Lamps.—The lamp most usually supplied with the ordinary phantasmagoria lantern of the shops is a fountain argand, with a flat reservoir, shown in Fig. 91, as in this case the illuminating material may be placed inside the body of the lantern with advantage, the oil being improved by warmth. The best illuminating material is good camphorised sperm oil. Two ounces of camphor should be moistened with a little alcohol, then pounded in a mortar, and to the magma thus produced, a pint of oil added, and stirred till dissolved. The argand burner must be so connected with the reservoir that the point of constant level is about 1¼ inches below the top of the wick. The chimney, C, somewhat conical in shape, is fixed to the metal gallery, G, by a brass screw-cap that overlaps a lip on the lower end of the chimney. The gallery also carries the air-cone, K, and in its external ring three slots are cut that drop over three pins terminating in ebony balls, B, B, that spring from the wick-regulator, R R. The wick is placed perpendicularly on a brass "wick-holder," W, from which projects a pin that fits a slot, S, in the "wick-adjuster," R, and also a serpentine groove cut on the inner side of the air-tube, A, of the wick-tube, T T. The wick-adjuster, R, is a tube that drops into the wick-tube, T T, outside the wick, and from the top of this tube springs a flange perforated so as to intercept as little air as possible from passing to the cone, K, as shown in the lower section (Fig. 92). On the slot, S, in the adjuster, R, being placed opposite the upper end of the serpentine groove in the air-tube, A, the pin in the wick-holder will fit into both, and the brass wick-holder will then drop into place between the two, but not in any other position. On rotating the flange from right to left the wick is worked to the bottom of the wick-tube, T, in which position it must be carefully cut off even with the top of the tube by a pair of sharp "shield-scissors," specially constructed for trimming lamps. On rotating the flange of the adjuster from left to right the wick is raised, and when about one-eighth of an inch above the tube it is in the best position for the brightest, smokeless flame, when the gallery with its air-cone and chimney is fitted over the adjuster.



The oil is carried from the flat reservoir by the delivery-tube, D, which opens into the wick-tube. An oil-cup, O, for receiving any overflow from the wick, screws on to the air-tube, A, its centre being perforated at *a* to encourage a free up-draught; the upper surface of this cup is also perforated to admit air to the central tube of the burner. A burette oil-can is a neat and clean contrivance for filling lamps—that is to say, a can from the bottom of which springs a narrow tube that is curved into a long spout on a line just below the neck. One of a pint capacity may be used as a store-bottle, in which case both neck and spout must be corked till required for filling the lamp, when both corks must be removed. After time has been allowed for the wick to get thoroughly soaked with oil, it should be lighted, allowed to burn for a few minutes, then blown out and re-trimmed with that exactitude that is essential to secure an even, smokeless, bright flame, and this can be better accomplished after the wick has been slightly charred. If the wick be soaked in strong vinegar, and then thoroughly dried before use, it will not char so readily. It need hardly be said that the metal-work must be kept clean, and lamp-glasses and reflectors thoroughly polished before use. The best reflectors are made of suitable thin concave glasses that have been silvered by Liebig's or Petitjean's process, by a deposit of pure metallic silver (not the ordinary mercurialised tinfoil silvering) on the convex side, protected by an electro-deposit of copper. Such reflectors are far more brilliant than the ordinary plated reflectors; they cannot tarnish, and only require wiping with a soft wash-leather to make them ready for use, instead of having to clean them with moistened rouge worked over with the pad of the thumb, and polish with a leather buff. Such mirrors must be guarded by a metal concave shield of a deeper curve than the back of the reflector, and be perforated to admit air for the purpose of keeping it cool.

Argand Gas Burners.—Until recently "Leslie's burner" held pre-eminence for light-giving qualities. This consisted of a series of small conical iron tubes converging from a broad connecting base in a conical form to a narrower centre. The chimney was arranged with an air-cone, so as to cause an up-draught between the several tubes and upon the flame. The drawback to this form of burner was the liability for the small tubes to become clogged by the corroding action of the gas. The most perfect gas argand at present attainable is the "London burner," a recent patent. It is well known that if house-gas be passed through the vapour of benzole, as recommended by the late Mr. Mansfield, who fell a victim to his experiments, the illuminating power is greatly increased; but the London burner gives a light very nearly equal to naphthalised gas, while the flame is short, cylindrical, steady, very bright and white, but, unless naphthalised, lacking in density. This burner is shown in section in Fig. 93. N, the napthaliser on which it is mounted, serves as a stand; I being the inlet-tap, and R the gas-regulator, a very essential part of this burner, through which it passes by three small curved tubes, T, T, T, to the argand burner, B, which is made of steatite, to render the exit-holes incorrodible, A being the central air-way. Outside the burner is a thin white metal air-cone, K K, supported by a gallery, G G, that also carries the glass chimney, C. The regulator consists of a solid conical point that descends from the top of the brass cap from which the three gas-tubes, T, T, T, spring, which fits into a hollow conical tube, or counter-fitting, that screws up into the cap, so that the flow of gas can be entirely cut off or admitted to full extent, being, in fact, a conical stop-cock that can be regulated to the veriest nicety by rotating the gallery, G G, to the left or to the right, the lower part being firmly screwed to the naphthaliser, N, or directly on to a gas-bracket or other supply-pipe. This regulator must be adjusted till the flame forms a perfectly bright cylinder about 1½ inches high, for if allowed to flare up the chimney the best result is not attained. Any stop-cock attached to the ordinary gas supply must be turned full on as the regulator takes its place, and there must be no check on the supply externally. This burner is made in three sizes: the smallest is suitable for microscopic lamps; the second I prefer to the larger model for magic-lantern work, as it gives a denser flame. The naphthaliser, N, is shown in section beneath. It consists of a cylindrical box, to the lid of which is soldered in a spiral coil a band of zinc nearly the depth of the box, that "beds" in a thick felt pad laid on the bottom, and terminates in the centre just beneath the hollow socket on which the burner is screwed. Benzole is poured in through this opening till the felt pad is well saturated, so that it may keep the spiral passage filled with benzole vapour. The gas passes in by the tap, I, and in its course to the central opening, E, becomes impregnated with the vapour, or, as it is termed, "naphthalised." Another form of "naphthaliser," used for photographic self-registering meteorological apparatus, is shown in Fig. 94. Its arrangement for making the gas pass over a long course of benzole vapour within a small compass is self-evident. The gas enters at I, and passes out at E. It is better to fill the passages with sponge-cuttings, as offering a larger surface from which the vapour can be given off. In winter, this arrangement may be supported over a water-bath heated by a small gas-jet, so as to ensure the vapour being given off during cold weather at a uniform temperature.

Flat Wicked Burners are very serviceable for microscopic illumination, especially if the thin edge, instead of the broad side, of the wick be turned towards the mirror, when fine markings are to be brought out.

A section of one of Dietz's flat-wick burners is shown in Fig. 95. As air is not passed through the centre of the flame, it is projected on to the flat wick by a slot cut in the large air-cone that stands above both wick and the lower part of flame.

Heavy Hydro-carbon Oil Burners are not much employed for scientific purposes; but there is one form of burner, patented by Holmes, that I think might be modified in form and made serviceable for microscopic illumination, as it gives a small but very bright jet of light. A small metal tube is closed at the upper end, pierced with a few minute holes, and packed with coarse lamp cotton. When the wick is saturated with heavy hydro-carbon oil, the end of the metal tube is warmed with a spirit-flame for a few seconds till the oil is vaporised and issues from the holes in the form of gas, when it ignites. The tube is then placed in the reservoir of the lamp, and the little jets continue to burn. Neither lamp-glass nor globe is necessary for this form of burner.

Fish-tail and Bat's-wing Burners.—These well-known forms of gas-jets are useful where glass chimneys would prove in the way, and where the equally compact lime-light burner would be regarded as too elaborate. Two fish-tails placed close behind each other produce an intense light. To prevent flicker through floor-draughts, these jets may be placed within a shallow three-sided box with the front side closed with a plate of glass, air being admitted from beneath by a series of well-distributed holes bored in a block of wood that serves to form the base of the arrangement.

Candles.—Sperm candles are employed as the standard of comparison with other lights; thus we say such a burner equals so many standard candles (six to the pound). Candles are made with single and double wicks implanted in tallow, "palm," "composite," stearine, wax, spermaceti, paraffine, ozokerit, etc. A Palmer's candle in its spring-tube to keep the flame at a constant point is a convenient arrangement for the travelling microscopist, especially if the tube be fitted in an adjusting clamp that can be fixed to the edge of a table, to allow of the point of light being raised or depressed. Night-lights are of great use to the travelling photographer, especially if made with paraffine wax, as a number can be packed in a cylindrical pasteboard case, that can be placed inside a yellow chimney, the whole being enclosed in a tin guard-tube (as shown in Fig. 96A), the lid of the same serving as a cup for the light and a gallery for the chimney when arranged for developing dry plates, etc., as shown in Fig. 96B.

Other Sources of Light.—In concluding the series of articles on "Sources of Light," in which I have endeavoured to describe the best type of each class of illuminating apparatus, it is only right to notice some that I have had no personal experience in, or may be regarded as little known inventions; thus there is the "Bourbouze burner," which is thus described:—

"The Bourbouze lamp is the name of a new French invention, which gives, it is stated, as much light as the oxy-hydrogen or Drummond lamp, but is very much less costly. The combustible is coal-gas intimately mixed with air. The mixture enters a tube, and then passes through a metallic plate pierced with a great number of small holes, so that the gas is divided into an infinite number of small jets. These play upon a tissue of platinum wire, and it is not until the gas has passed through this tissue that it is lighted. Under the influence of the heat produced, the platinum soon becomes white hot, and it is then impossible to look at it with the naked eye. The gaseous mixture is forced through the system by a slight pressure; about one cubic metre of gas is consumed per hour."

Similar in arrangement is the apparatus of Mr. Hogg, of Edinburgh, which is constructed in the following manner:—"Two tubes are employed on the Bunsen lamp principle, one of which is of smaller diameter than the other, and the said smaller tube is placed within the larger tube. One tube is placed in communication with condensed gas, or air, or with both, such gas or air being compressed by a pump or other suitable apparatus for compressing or condensing air, or gas, or aëriform or gaseous fluid. This pump or apparatus may be of ordinary construction, and may be worked by hand, steam, or other power. The other tube is placed in communication with ordinary arrangements for the supply of atmospheric air or gas thereto. The gas or the air, or both, may be supplied at any determined pressure, or it or they may be condensed or compressed (before reaching the tube or tubes) in a pump or apparatus for the purpose of ordinary construction. The mixture of gas and air is passed through a perforated plate of platina or other suitable material, or a tissue of platina wire gauze, or other suitable wire gauze, by which it is divided into numerous small jets. The mixture of gas and air is obtained thus—that is to say, one of those agents is conducted through the smaller tube and discharged through the opening thereof into the larger tube, into which also the other agent is admitted. The tubes thus act as a sort of blow-pipe. The aëriform or gaseous mixture passes through the larger tube to a piece or surface of fine platina. Pierced plate, or wire gauze, or woven platina wire, or other suitable metal, may be substituted for the platina. The minute jets pass through the interstices of the platina or other material, and are ignited. The metal soon becomes incandescent, the supply of air being duly regulated, combustion is made perfect, flame disappears, and the platina or metal becomes a surface of intense light. Sometimes, instead of using a mixture of gas and air, compressed or condensed gas by itself and air at the ordinary pressure are used. Sometimes the gas and air may be heated before burning, to obtain a maximum effect."

An arrangement wherein atmospheric air under pressure is driven through a small tube coiled into a spiral and heated by a lamp, passes out at a blow-pipe nozzle through a spirit or house-gas flame on to a lime-ball in the manner of the oxy-calcium jet. Such an arrangement, if effective, would be economical, and save the trouble of making oxygen, while the size of the reservoir would be greatly reduced. I hear this spoken of promisingly, but as yet I fear it can only be regarded as an undeveloped source of light.

TECHNICAL DRAWING.—LXX.

DRAWING FOR BRICKLAYERS (*continued*).

COMMON DOUBLE FLEMISH BOND.

DOUBLE Flemish bond implies that this bond appears on both sides of a wall. In double Flemish bond it is the custom in some parts to use alternate stretching courses on both sides of the wall—that is, courses in which false headers or bats are combined with stretchers. Thus two rows of fissures or unbroken joints, each 9 inches in length, and at intervals of 4 inches apart, are produced, one near the face and the other near the back of the wall, each being at the distance of half a brick from the adjacent surface of the wall.

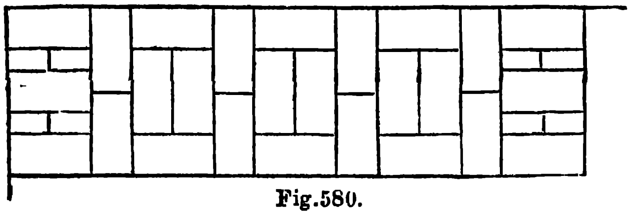


Fig.580.

Fig. 580 is the plan of one course of a portion of a two-brick wall, built according to double Flemish bond.

"Hence," says Sir Charles Pasley, "on comparing those two arrangements, it will be evident that both sides of a wall are weak in a common double Flemish bond, whilst in the common single Flemish bond one side of the wall only is defective. The common double Flemish bond is therefore a very imperfect arrangement, which never ought to be used at all, and, to the best of my knowledge, is never used in the walls of a building by any skilful bricklayer. On comparing together the various kinds of brickwork, it appears to me that the common English bond is by far the simplest and strongest, and that it ought therefore to be always used in preference to Flemish bond, which is sure to leave one side of the wall weak, and to a certain degree liable to split by longitudinal fracture."

English bond is not only much stronger in itself than Flemish bond, but it has the great advantage, which the other does not possess, of being able to alternate occasionally in a substantial manner with one or more diagonal courses of brickwork in walls of two bricks in thickness and upwards. This useful arrangement we will now proceed to explain.

DIAGONAL BOND.

In thick walls, but more especially in foundations, a third kind of bond, called diagonal bond, is sometimes used. This consists in laying certain of the courses of bricks at right angles to each other, and oblique to the surface of the wall, with which they form at every part an angle of about 45°*

In adopting this arrangement, intermixed with English bond, the diagonal bricks in those courses do not extend so far as the face or back of the wall, where a line of common heading or stretching bricks is laid in the usual manner: thus the wall, when finished, has all the appearance of common English bond.

A two-brick wall is the thinnest in which diagonal courses can be used combined with English bond, and in this case only with the stretching courses. Figs. 581, 582, and 583 represent this arrangement, in which are introduced, first, a heading course of common English bond (Fig. 581); secondly, a diagonal course between the stretchers (Fig. 582); after this, a second heading course, and then another diagonal course between the second set of stretchers (Fig. 583) at right angles to the former.

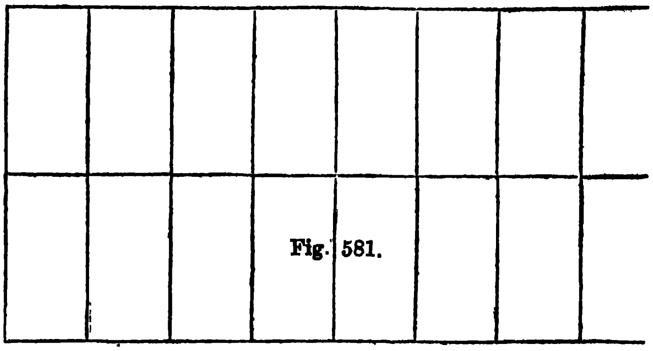


Fig. 581.

The triangular spaces at the extremities of the diagonal bricks between them and the common headers or stretchers at the external surface of the wall must be filled in with bats or fragments cut to the same form.

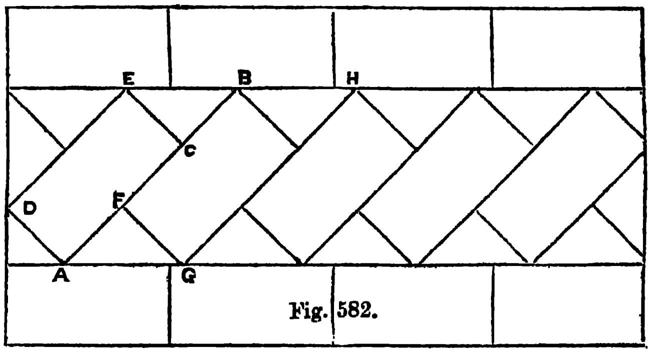


Fig. 582.

Sometimes the bricklayer, instead of using all fragments, will cut the end of a whole brick obliquely, so as to meet the outer row of headers or stretchers, in which the diagonal bricks are enclosed. But this precaution seems scarcely necessary if the interstices arising from the former method be well filled up with solid pieces, instead of being simply stuffed with mortar.

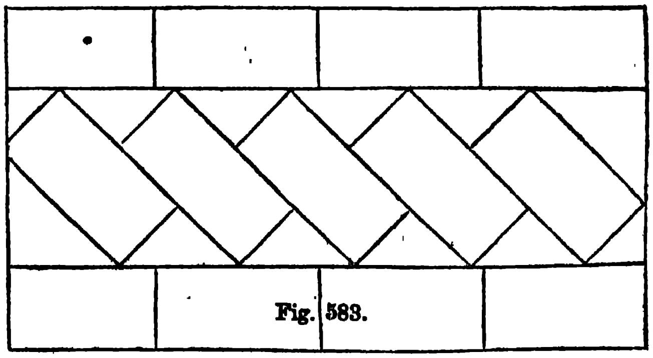


Fig. 583.

Although Figs. 582 and 583 appear very simple, some little care is necessary in drawing them. It must be borne in mind that the bricks, though placed obliquely, are *not altered in their rectangular form*—a fact which students often overlook. The following method is therefore given.

Having drawn the parallel lines representing the total thickness of the wall, and having drawn lines within these at distances equal to the lines of headers or stretchers which are to form the faces of the wall, draw a line at any point, as A, at 45° to the line of the wall—viz., A B (this will, of course, be done by means of the set-square of 45° worked against the T-square); reverse the set-square, and from A draw A D. The space between these two lines will then be the right angle D A B. Now on A B set off A C equal to the length of a brick, and from A mark off on A D the width of a brick. From C and D draw lines parallel to A B and A D, which meeting in E will complete the rectangle representing the brick, the point E, if the work be correctly done, falling on the line bounding the space to contain the diagonal course.

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* One diagonal brick laid at an angle of 46° 24′ with the face of the wall occupies the space of one header in the thickness. The bricklayer finds the proper angle by trial. The angle of 45° is therefore only approximate, and is here used for convenience in drawing.

From B set off B F equal to A C, and from F draw F G; from G draw G H, and in this way the work will proceed.

The use of diagonal courses consists in producing a more powerful bond than the lap of a quarter brick only, which is all that the common English or Flemish bonds are capable of yielding; and there is no possible way of laying the diagonal bricks wrongly, for if they be intermingled with common English bond, according to the rule given, one, two, three, or more whole bricks laid diagonally will just fill up the core of the wall, in proportion to its thickness; and all the successive courses of those bricks will break joint properly, whether in reference to each other, or to the common courses of English bond, above or below them. This may easily be proved by building a wall, as above described, with the model bricks.

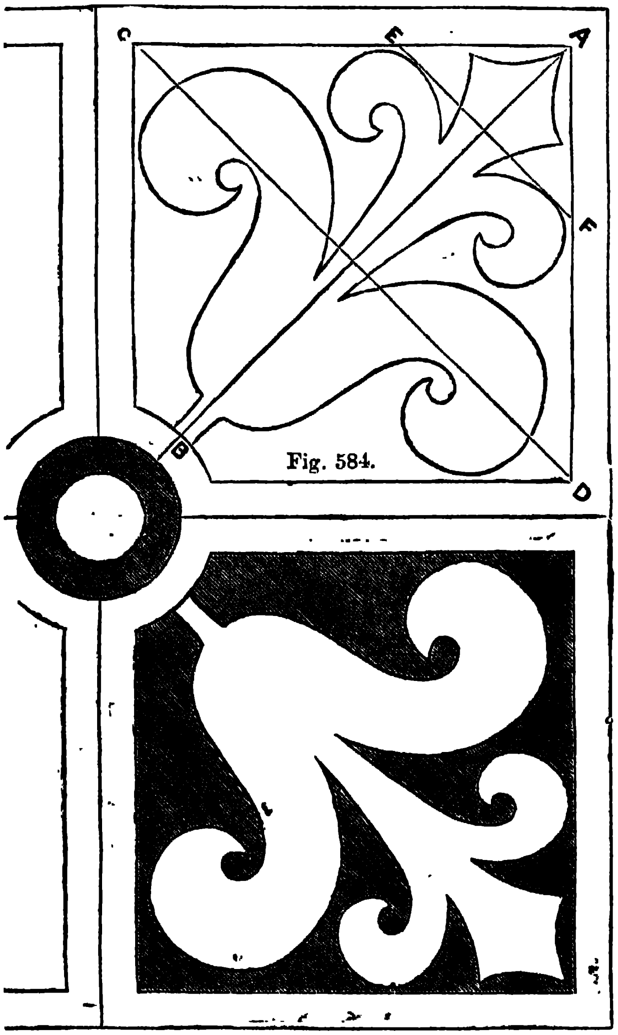


Fig. 584.

The student will observe that in thus combining the diagonal courses with English bond, the same effect will be produced by throwing in the courses of diagonal bond singly, instead of using two in succession. For example, after one course of English bond, might come one diagonal course, then another course of English bond, after which might follow the second course of diagonal bond. But whichever arrangement be adopted, the successive diagonal courses ought to be laid in contrary directions.

Diagonal courses laid as here described are sometimes called "herring-bone bond." This term is more correctly applied to the method by which the direction of the diagonal bricks in the core are reversed in the same course. Diagonal bond is further illustrated in "Building Construction" (Vol. I., p. 172).

FREEHAND DRAWING.

The example here given (Fig. 584) is a design for an ornamental floor-tile. The entire tile would be square. This portion, being half of the whole, consists of course of two squares, each square representing a quarter of the tile, which thus consists of four repeats of the same ornamental form. Having drawn the two squares, proceed to draw diagonals in each, corresponding with A B C D. Draw the centre lobe of the ornament, using A B as the centre line. The curves, turning in a continuous direction, bend outward, and are kept balanced by the line E F, parallel to the diagonal C D. The rest of the figure will be easily followed from the example, care being taken in the exact balancing of the sides.

As it is intended that the student should complete the tile, he should draw the whole square at starting, and divide it into quarters; the diagonals are then to be drawn in each of these smaller squares, and as any single part of the ornament has been sketched in one compartment, it should be repeated in each of the others respectively, until the whole is completed; by this means each line can be singly compared with the others, and thus the balancing of the forms will be facilitated.

When the whole outline has been carefully revised and "lined in," the design may be coloured: the ground may be black and the ornament Venetian red; or the ground may be blue and the ornament orange; or the ground may be crimson and the pattern green, or any such combination, according to the taste of the student. It must, however, be remarked that, since the floor-tile is intended to ornament a perfectly flat surface, no attempt at shading must be made, since shading has the effect of causing the form to appear to be raised, or to stand up from the surface; and it will easily be understood that anything approaching *raised* ornamentation would be out of place on a floor.

The colours used for colouring this and similar designs are not the usual cakes supplied in colour-boxes—though, of course, those would answer the purpose if others cannot be obtained—but, owing to the transparency of most cake colours, it is rather difficult to cover surfaces evenly; and in this example the spotty appearance thus caused is very disagreeable, whilst much time would be spent in "stippling" up the work.

The colours best adapted for this purpose are those called "body-colours." They are sold either in powder, or in some cases, in lump, by the artists' colourmen. These are ground up, first with water, and then with the addition of a little gum arabic, white of an egg, or weak size. Very good body colours may be obtained under the name of "moist colours," in metal tubes, which are found to answer the purpose very well. They are more expensive than the powder colours, but are more finely ground, and are mixed with gum, or other medium, requiring only the addition of water to be ready for use.

LINEAR DRAWING (*continued*).

BRICK ARCHES.

The general principles of arches having been elucidated in "Building Construction," it will be unnecessary here to repeat the lesson. We will, therefore, only remind the student of some technical terms used in relation to arches, such as the *piers* and *abutments*, which support them; also the *span* or width, and the *rise* or height of an arch. The *skewbacks*, or sides of the ring of brickwork, when the arch does not spring from a horizontal plane; the *haunches*, or lower segments of each side, as distinguished from what common bricklayers call the scheme part, or upper segment of the arch; the *intrados*, or whole interior, or the lower surface; the *extrados*, or whole exterior, or upper surface; the *crown*, or summit of an arch; the *voussoirs*, or arch-stones; and the *key*, or *keystone*.

The various kinds of arches—such as straight, segmental, stilted, Gothic, etc.—have also been described in the articles on "Building Construction."

The arches used in buildings of any importance are of two kinds—external and internal.

The former are executed with great care, and in an ornamental manner; the latter are done strongly, but roughly, being afterwards concealed from view by the inside finishing of rooms, etc.

CIVIL ENGINEERING.—XVIII.

BY R. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES (*continued*).

The name of Smeaton will ever be associated with the Eddystone. It was upon these weather-beaten rocks, which had already borne two lighthouses, one of which was destroyed by water and one by fire, that the great engineer was to erect the monument which for nearly 120 years has nobly withstood the buffetings of the elements.

It is worthy of note that at the time Smeaton was recommended by the then President of the Royal Society, the Earl of Macclesfield, for the task of rebuilding the Eddystone Lighthouse, he was not an engineer either by profession or education. A philosophical instrument maker by trade, he confesses that when he commenced his designs he was a total stranger to such structures. He had, however, studied very carefully the character of the two previous lighthouses; and whilst he was prepared to retain all the good points in them which presented themselves to his judgment, he was ready to bring his great genius and large stock of common sense to improve upon their weak points, and altogether abandon their faulty ones.

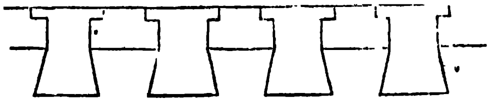


Fig. 39.

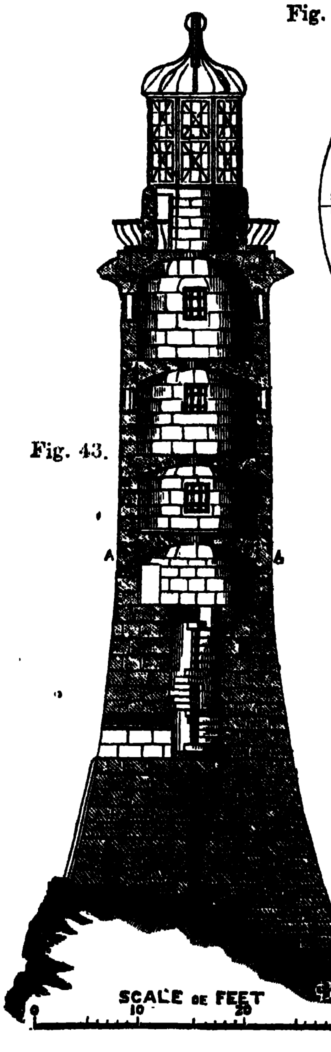


Fig. 43.

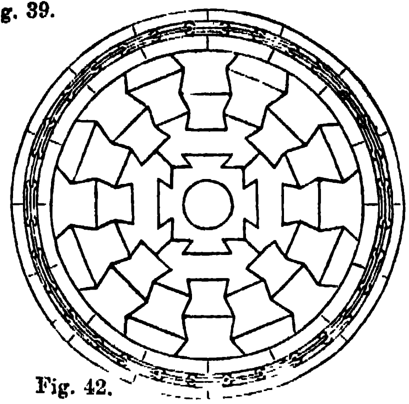


Fig. 42.

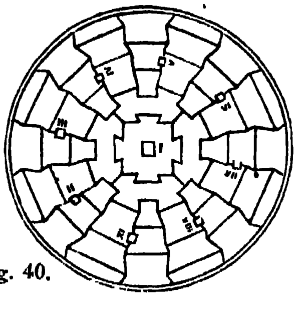


Fig. 40.

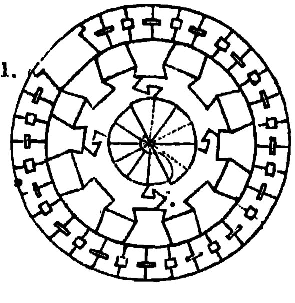


Fig. 41.

What his views upon the matter were we shall best explain by quoting the drift of his own words. He says, "It appeared evident that had it not been for the courses of moorstone (in Rudyerd's structure) inlaid with the frame of the building, and acting like the ballast of a ship, it would long ago have been upset, notwithstanding all the branches of iron-work contrived to retain it; and that in reality the violent vibration which the late building was constantly subject to, had rendered its base or seat in some degree rounding, like the rockers of a cradle. It seemed, therefore, a primary point of importance to procure, if possible, an enlargement of the base. It also seemed desirable to adhere strictly to the conical form, or at least to a modification of the conical form." He observes, in reference to the true cone, "The necessary consequence would be, that the diameter of every part being proportionally increased by an enlargement of the base, the action of the sea would be greater upon the building in the same proportion; although as the strength increases in proportion to the increased weight of the materials, the total absolute strength to resist the action of the sea would be greater by a proportional enlargement of every part, *but would require a greater quantity of materials.* On the other hand, if we could enlarge the base, and at the same time rather diminish than increase the size of the waist and upper works, as large an amount of strength and stiffness would arise from a larger base, accompanied with a less resistance to the acting power, as if a similar conical figure had been preserved, whilst at the same time *a less quantity of material* would be employed." A stone edifice having been determined upon, the engineer, following up the mode of reasoning stated, decided upon giving his structure the waist of a large spreading oak. He made a model in wood, having a small degree of tapering, and then fitted it to the oblique surface of another block—the surface of the Eddystone being sloping—and found that by arranging the several curves, they could be firmly united to form an efficient foundation. The model having given satisfaction, the works were ordered to be commenced forthwith.

Before proceeding further with an account of the construction of Smeaton's lighthouse, we wish to direct the attention of our readers to the paragraphs we have italicised. It will be observed how careful the engineer was to avoid the unnecessary employment of material, and by what a happy train of reasoning he arrived at the method of doing so. Well would it be if, upon every occasion, the engineer sufficiently studied the design he has to carry out, and the work he has to do, as that just so much material as is necessary should be employed, and no more. It is an absolute fact that there are many engineering operations which are actually *weakened*, by the unnecessary employment of material. The work is burdened with weight, and the material which adds to the weight adds not the least atom of strength to the design; expense is unnecessarily incurred, and often the design is rendered clumsy and unsightly. We purpose referring more particularly to this important feature in engineering works, the useless employment of material, in a subsequent paper.

Having definitely decided upon the material to be employed, and the form to be given to the lighthouse, Smeaton's thoughts were next directed to the best method for uniting his stone blocks. He had, after careful inquiries in the neighbourhood, decided upon using moorstone for the basement and lower portion of the building, and Portland stone for the upper portion. Accordingly, he contracted for 240 tons of the former, at 25s. per ton roughed out, and 4d. per foot superficial for working the beds. This price, however, did not include the cost of conveyance to the rock, but only to the yard at Plymouth. The moorstone is taken out of the quarry by splitting it with a number of wedges driven into notches or grooves cut in the surface about 4 inches apart, more or less, according to the size and strength of the block. The holes are sunk with the point of a pick. The mode of quarrying the Portland stone has been alluded to in our description of the Portland Breakwater. The manner of uniting the blocks deserves careful attention. At first Smeaton's thoughts were directed to iron cramps, but after mature thought this plan was rejected; then the idea of dovetailing, as employed in woodwork, occurred to him. He had seen something of the kind in a description by Belidor of the stone floor of the great sluice at Cherbourg, where the tails of the upright headers are cut into dovetails, for their insertion into the mass of rough masonry below. (See Fig. 39.)

"From these beginnings," he says, "I was readily led to believe, that if the blocks themselves were, both inside and out, all formed into large dovetails, they might be managed so as mutually to lock one another together, being primarily engrafted into the rock; and in the round and entire courses above the top of the rock they might all proceed from, and be locked to, one large centre stone. It is obvious that this method of dovetailing, while the slope of the rock was made good by cutting the steps formed by Mr. Rudyerd also into dovetails, it might be said that the foundation-stones of every course were engrafted into, or rather rooted into the rock; which would not only keep all the stones in one course together, but prevent the courses themselves, as one stone, from moving or sliding upon each other. But after losing hold of the rock by getting above it, then, though every stone in the same course would be bonded in the strongest manner with each other, and might be considered as a single stone, which would weigh a considerable number of tons, and would be further retained to the floor below by the cement, so that, when completed, the sea would have no action upon it but edgeways; yet as a force, if sufficiently great, might move it, notwithstanding its weight, and the small hold of the sea upon it, and break the cement, before time had given it that hardness which it might be expected to acquire afterwards, I had formed more expedients than one for fixing the courses to one another, so as absolutely to prevent their shifting." Such is Smeaton's description in his own words of the method he proposed to adopt in uniting the component pieces of his work, and the reason of his doing so. We shall see how well he carried out his purpose.

The mortar used was compounded of blue lias lime and puzzolana in equal quantities, prepared by beating it up in a strong wooden bucket with a wooden pestle. The lime, in quantities of a quarter of a peck at a time, was beaten first, and when formed with sea-water into a thin paste, the puzzolana was gradually added whilst the beating was continued.

The system of dovetailing determined upon, necessitated an immense amount of labour upon each individual block, and the accuracy required in fitting the pieces together rendered it desirable to arrange each course in a completed state, which could then be taken to pieces for transport to the rock. Application was made to the Mayor of Plymouth to permit the temporary use of one of the municipal buildings for the purpose of fitting the courses together, but it was refused; and a shed was hired for the occasion. The greatest care was requisite to prevent any confusion in the relative position of the stones. For this end, each stone was marked or numbered, and lines were drawn across the middle of each tending to the centre. The result of this precaution was that no difficulty or delay occurred in bedding the stones into their position upon their arrival at the rock. We subjoin plans of a few of the courses, showing the method of jointing adopted. Fig. 40 represents the first course, which was composed wholly of hewn stone. It is the seventh from the bottom course, which latter consisted only of four hewn stones, lying as it did at the bottom of the slope of the reef. The stones increased gradually in number in each course from the bottom until the seventh was reached, consisting of four, thirteen, twenty-five, twenty-three, twenty-six, and twenty-six stones each respectively. As one stone or more of each of these six bottom courses were engrafted in dovetail recesses cut into the solid rock, there could be no danger whatever arising from the horizontal force of the sea acting against them; but the seventh course rising entirely above the rock, a plan was adopted by the engineer for producing an artificial arrangement which should cause a similar effect. This plan was as follows:—In the centre of the sixth course, and in eight regular positions around this centre, holes were cut in the stone 12 inches square. The centre-hole was 13 inches deep, and the remaining eight were 6 inches deep. Into these nine holes, blocks of hard marble from the Plymouth rocks, 12 inches square, were introduced, and securely fixed in their positions by mortar and wedges. Corresponding holes to these marble blocks were cut in the proper stones of the seventh course, as shown by the figures in Fig. 40; and the projecting ends of the blocks were introduced in them, and were thus most immovably fixed against any force acting horizontally.

In this manner seventeen more courses were carried up, the whole being solid, with the exception of the winding staircase and entrance doorway, which commenced on the fourteenth course from the bottom. A height of 27 feet above ordinary spring-tide high-water mark was thus attained, and at this point the hollow or habitable portion of the building commenced. In Fig. 41 we give a plan of the twenty-fourth course, in which the dovetailing arrangement of the exterior stones is shown. This system was adopted at this stage, because the building lacked the benefit of the interior stones to tie the several courses together. The diameter of the building immediately above the rock is 25 feet, but at the course shown in Fig. 41 it was reduced to 16 feet 8 inches, the rooms being 12 feet 4 inches in diameter, and the walls 13 inches thick. The walls were composed of single blocks of moorstone, sixteen in each course, cramped with iron, and joggled at each joint. The joggles are of sawn marble 8 inches long, 4 inches broad, and 3 inches thick.

At the twenty-eighth course the vaulted floor forming the ceiling to the upper store-room was introduced, and into this course was laid the first circular iron chain, which was lodged in a groove cut round the middle of the upper surface of the stones. The necessity for this chain, shown in Fig. 42, which represents the twenty-ninth course, marked A A in the section (Fig. 43), will be apparent from the nature of the construction of the floor resting upon this and the course above.

By reference to the section it will be seen that each floor rests upon two courses, and although arched it has not the benefit of sloping abutments to support it. Had each floor consisted of a single stone, there would have been no outward thrust to provide against; but being made in pieces, it had the same tendency to thrust the encompassing walls outwards, as the component stones of an arch; although, irrespective of the encompassing chain, the system of dovetailing which was also introduced in the floors tended to mitigate the evil of the lateral pressure.

Smeaton adopted the endless chain by a consideration of its value in the cupola of St. Paul's Cathedral, where it had been introduced by Sir Christopher Wren. Each of the floors is encompassed by two endless chains, the bars or links of which are 1¼-inch square, and the grooves receiving them are 4 inches deep and wide. After each chain was laid in the groove 11 cwt. of lead was run in.

The height of the main column containing forty-six courses is 70 feet, and its diameter at the top 15 feet. The lantern is formed almost entirely of copper. It consists of sixteen frames, with nine panes of glass in each. The lantern is 24 feet high, and the diameter 9 feet. The light was originally derived from a chandelier 6 feet 4 inches in diameter, to contain sixteen candles; and a smaller one within and above it, 3 feet 4 inches in diameter, to contain eight candles. In 1807, however, the chandeliers were removed, and a reflector-frame substituted, fitted with argand burners, and parabolic reflectors formed of copper, covered with highly polished silver.

Smeaton completed this elegant and substantial building in rather less than three and a quarter years.

We shall present to our readers the description of another lighthouse, as being an excellent specimen of marine engineering, the Bell Rock Lighthouse, erected by Mr. Robert Stevenson. The Bell Rock is situated in the German Ocean, eleven miles S.W. from the Redhead, in Forfarshire. The rock is a red sandstone, the surface being very rugged and full of cavities. The north-east end is the highest portion of the reef, and is partially left dry at low water of neap tides, but the lower level is only visible at springs. The spring tides here rise and fall 15 feet, and the neaps 9 feet.

In 1806 an Act of Parliament was passed to construct a lighthouse upon this rock, and it was decided by the Commissioners to adopt a design similar to the Eddystone. Owing, however, to the nearer coincidence of level between the Bell Rock and the mean level of the sea, as compared with the Eddystone, the operations were greatly more difficult at the outset. The commencement of operations was ushered in by mooring a vessel, fitted out as a light-ship, about one and a-half miles N.E. of the Bell Rock, to be employed as a tender during the first season's operations, to which the artificers retired whilst the rock was covered with water. The distance of the nearest land from the rock being so great, and the set of the tide so strong, the advantage of a place of refuge at so short a distance is obvious. The light-ship was moored in twenty-two fathoms of water, her moorings consisting of a mushroom anchor weighing 33 cwt., and a heavy chain, to which she was attached by a hempen cable 14 inches in circumference; and at these moorings she rode without accident for four years. The method of lighting this light-ship was peculiar. The vessel had three masts, and each mast was fitted with a cylindrical lantern, the mast passing through its centre. Each lantern contained ten lamps, with as many silver-plated reflectors, arranged around the mast, so that on no side was the light obscured.

Early in 1807 stones were collected from the granite quarries of Rubeslaw, in Aberdeenshire, for the *outside casing* of the first 30 feet from the base, whilst sandstone for the interior or hearting of the solid portion, and for the upper portion of the building, was procured from Mylnefield quarry, near Dundee. The cornice and parapet wall of the light-room were prepared at Edinburgh, and the stones taken from Craigleith quarry. A piece of ground at Arbroath was leased for a work-yard, and here materials were laid down, and workmen collected; sheds also were constructed, and a barrack erected for the accommodation of about 100 artificers. Operations were commenced at the rock itself in August, 1807.

MAP AND PLAN DRAWING.—II.

By C. C. King.

SCALES — COMPENSATING INSTRUMENT — TRIANGULATION: BASE-LINE OF SURVEY, ETC.—SURVEYING CHAIN—LEVELLING—CONTOURING—DELINEATION OF MAPS AND PLANS.

So far, then, we have only obtained a single definite point on the actual surface to be surveyed, and the means of transferring it relatively to the paper on which the projected meridians and arcs of latitude are drawn. The results of the various steps which have now to be taken may either be immediately represented as they are taken, which would only occur in smaller surveys, or, when calculations and corrections have to be entered into, this may be deferred till the work is more advanced. Ultimately, however, the representation must be produced, and then the question of the scale to which the map is to be made has to be considered.

A scale is merely the relation that exists between any dimension on the true surface, and the same as represented on the map. The size of the map, therefore, entirely depends on the scale that is selected, and this is again determined as a rule by the size of the paper on which the map is to be drawn. Thus, if the extreme limits of the area are 1,000 miles laterally, and the size of the paper is about a foot square, the scale will have to be one of 1,000 miles to 10 inches, suppose, or 100 miles to the inch; by which it is inferred that every inch on the map corresponds to 100 miles of true measurement, and that if therefore the inch be divided into 100 equal parts, each one may be considered to show the relative value of one mile on our paper. This is the principle on which scales may be constructed, and practically are so on smaller sketches where the space available for drawing is the chief consideration; but there are numerous scales already prepared for convenience' sake on the ivory or wooden protractors and "scales" in every box of mathematical instruments to suit ordinary maps. Thus we usually find the inch divided into 20, 30, 35, 40, or 45 equal parts, representing so many different proportions of miles, yards, or feet to the inch, and numerous other subdivisions of the same unit, such as twelve parts to the inch, useful in a large scale where feet and inches alone are the principal dimensions. In English maps the "scale" is usually denoted as one of so many miles to the inch: thus in the Ordnance Survey we find one mile to the inch; but in Continental maps it is represented by a fraction, giving the ratio of the map to the actual area, as, for example, $\frac{1}{100000}$ or $\frac{1}{63360}$. The latter fraction is but another method of defining one mile to an inch; for

The ratio of the map : the true area : : 1 : 63,360.
: : 1 inch : 63,360 inches.
: : 1 inch : 1 mile.

In either case, the scale is actually drawn on the map, a convenient length being taken which is divided into the required number of parts, and if it be large enough, the left-hand division is further marked off into a certain number of small ones, to admit of more minute measurement. Thus if the principal divisions show lengths of ten miles, the first will contain ten equal and smaller portions. Standard atlases generally contain two or three scales for different purposes, as, for example, those of geographical or Italian miles, of which there are 60 to a degree; French kilometres of 111·307 to a degree; German geographical miles of 15 to a degree; and lastly, the scale which is appended to every English map, the statute mile of 69·16 to a degree.

The scale then being determined, the survey can be proceeded with. The base-line has to be measured, and carefully aligned, so that its length and position may be marked on our skeleton map, as well as furnish one absolutely accurate side for the first triangle of the triangulation. For this purpose a theodolite, of large size usually, is fixed at one extremity of the base, and remains there during the whole of the operation, to prevent any lateral deviation from the straight line during the measurement. Rods are planted in the ground at intervals of from a half to three-quarters of a mile, and the inner edges of these are carefully aligned by means of the telescope of the instrument. The starting-point is marked by a block of stone carefully fixed and levelled, and having on its upper surface a metal plate containing a minute point carefully marked.

Various materials have been used for measurement, owing to the absolute necessity for exactitude, and the difficulty of regulating or calculating the alterations made by the expansion of the measuring bar at different times of the year or even at different times in the same day. Thus steel chains, glass, platinum, or deal rods made into rigid wands, have been employed in various instances, and the latter material was used in the re-examination of the Hounslow Heath base, first determined by steel chains in 1784; but in using any of these the temperature has to be noted as every chain is laid, for the expansion of the materials varies with the temperature, and there was at that time no arrangement for making the instrument itself correct its own inaccuracies from this cause.

A more perfect apparatus has been devised for modern surveys, which approaches as nearly as possible complete accuracy. It is a compensating instrument, the construction of which is based on the principle of the unequal expansion of metals. Two rods of iron and brass, about ten feet long, are welded together at their centres, and laquered so as to equalise the influence of the variations of temperature on them. At their extremities are attached two tongues of iron, fixed at right angles to the bars and projecting beyond them, and on their outer parts a minute point of platinum is inserted. The action of the expansion is as follows :—

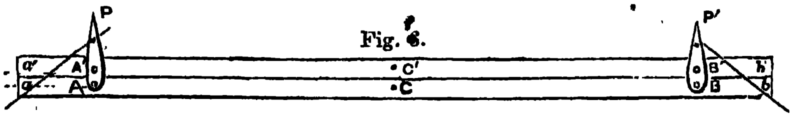


Fig. 6.

Let A B and A′ B′ (Fig. 6) be the two rods united at C C′, and let A P and B P′ be the metal tongues. Now A′ C′ and A C are equal to one another at a given temperature; but if the rods expand to the points a' a and b' b the position of the points P and P′ are unaltered. For assume the increase of temperature to be t, and the coefficient of expansion to be m; then

$$Aa = AC \cdot m \cdot t;$$
$$A'a' = A'C' \cdot m \cdot t;$$
$$\therefore \frac{Aa}{A'a'} = \frac{m}{m'} = c \text{, a constant.}$$

But $$\frac{PA}{PA'} = \frac{Aa}{A'a'};$$

Therefore $$\frac{PA}{PA'} = \text{a constant.}$$

That is, A P is independent of the temperature t; and even though expansion occurs, the position of P, or P′ by similar reasoning, remains unaltered.

The distance P P′ is accurately adjusted in the construction of the instrument. These rods are then placed in boxes for the sake of preservation, the points or tongues projecting beyond them, and levels and telescopic sights are fixed to these outer casings both to align the successive bars and level them. They are carefully set up on small platforms resting on trestles, and aligned and levelled by means of "small motion" screws. Five of these instruments were used in the measurement of the Irish base, and after being brought into the alignment another instrument was employed to overcome the difficulty of bringing the points of any two bars in exact contact or juxtaposition. A powerful double microscope, fitted in a compensating frame, of similar character to that of the bars themselves, was placed between two bars. Spirit-levels were attached for adjustment and a telescope for alignment, and the two lenses of the instrument, which were exactly six inches apart, were furnished with micrometric screws, which enabled one of them to be focussed over the platinum point at the extremity of a bar. The microscopes being rigidly fixed to one another, so as to preserve their relative distance, the point of the adjacent bar was brought beneath the lens of the remaining microscope by means of the small motion screws provided to give the measuring rod a slight lateral motion. Thus five bars, giving a length of fifty-two feet, were laid at one time, and the rate of progression was about 250 feet per day. In order to transfer the extremity of the last measurement taken on each occasion to the ground, and enable the work to be carried on the following day, a microscope with a long focus was fixed mid-way between those above described, and a block of stone protected by an iron cover, in which there was a brass disc containing a small silver plate, was securely embedded in the earth, immediately below the focus of the central microscope of the frame. Extreme care was taken lest this should be disturbed, and it was therefore covered at night by a wooden cover and watch kept over it.

Fig. 8.

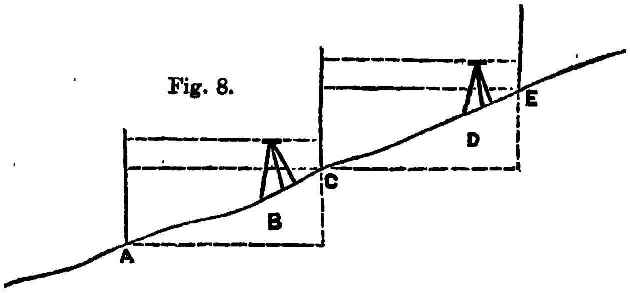
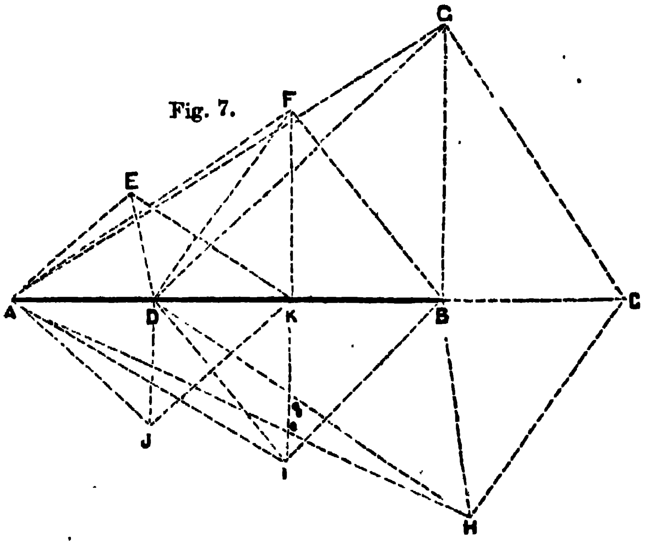


Fig. 7.



Thus the base-line of the survey is most carefully determined, and even if a sufficient length cannot be obtained by actual measurement the length can be extended, provided a considerable line has been measured, by a system of triangulation based on the portion already traced. The accompanying figure (Fig. 7) will explain this. The only thing to be noticed is that the points E, F, G, H, I, J, are clearly visible from the starting-point A, and are nearly at right angles to the points D, K, B, which have been carefully noted and fixed during the measurement. The various parts of the triangles are thus determined, until finally the measured base A B is extended by calculation to the point C (Fig. 7).

Before the base can be considered complete it is reduced to the horizontal plane, if there are any irregularities in the surface over which it has been conveyed, and finally to the level of the sea. This is necessary in accurate work, as the arc actually determined is greater than that which would be measured on the surface of the sea, to which all heights and dimensions are referred, on account of the sphericity of the earth.

Having completed the determination of the base-line, the more prominent or most central and convenient points are fixed for the greater triangulation. Powerful theodolites are used for this purpose, and care is taken that the triangles are as nearly equilateral as possible, so as to avoid the inaccuracy taking very acute angles would induce. The theodolite is simply a telescope fitted on a stand, and capable of receiving movement in a vertical plane, for which purpose it rests in a support, provided with a vertical graduated arc working on carefully adjusted points, and also partaking of a horizontal movement. This is arranged by having the upper telescope frame referred to fixed on a metal disc, having a vernier, which works smoothly and accurately on a lower one, which is graduated on its circumference from zero to 360°, and which admits of being levelled by means of vertical "plate" screws. Two spirit-levels at right angles to one another are fixed for this purpose on the upper plate, which is moreover bevelled or chamfered on the edge to form a sloping surface on which the angular measurements taken can be the more easily read.

The triangulation proceeds from the base-line in a series of gradually increasing triangles, and these are repeatedly taken, their means carefully calculated, and their reduction to the true surface completed by mathematical calculation. A very large theodolite is used for this portion of the survey, and as the distances between the points of the triangles were frequently very great, or, as in the case of the distance between London and Shooter's Hill, much obscured by the smoke of the City, an ingenious device was employed to enable these long sides of the triangles to be ascertained. A reflector is placed at one of the points, and constantly moved so as to reflect a ray of light in the known direction of the other extremity of the line. The observer there directing the telescope of the theodolite in the direction of the reflector, moves the instrument over a very small field by means of the "small motion" screws, until a ray of light is reflected into it; the telescope is then allowed to remain stationary until a second ray verifies the accuracy of the preceding observation. Great distances have been readily fixed, and points forty-five miles apart have been thus determined.

When the greater triangulation is completed, the minor points, those of less importance, are united by a series of smaller triangles, until we can finally mark down on the map the relative position of all the prominent natural and artificial features of the area, the whole of which, with the exception of the base-line, have been fixed by mathematically corrected trigonometrical calculation. The remainder of the work is done by absolute measurement with a chain, the small theodolite being still used for correction, and to determine the bearings of the points with regard to those of the greater triangles.

The surveying chain is a metal chain composed of iron wire links, one hundred in number, connected by oval rings, the extremities being terminated by swivels and open handles. It is divided into ten equal parts by pieces of brass which are loosely attached to the chain, and which are divided at their outer ends into as many projections as will indicate the number of links at these points from the ends of the chain. In using it it is carefully stretched straight, and the workman carrying the front end marks the point at which the extremity rested by a small metal rod or arrow of which he has ten, and the second surveyor, after advancing to the point and aligning his end of the chain with it, removes the arrow and carries it until the whole ten remain in his hand. This serves to correct the number of times the chain has been used in any measurement, as it would be at any time indicated by the number of arrows. Corrections have to be made for temperature and for sloping ground, and much skill is required, and frequent adjustment of the chain to a standard measure is essential to accurate work.

By these means the whole of the area treated as a plane surface—that is, without reference to its differences of level—will be mapped. It now remains, therefore, to find the different altitudes of the various elevated portions, and to ascertain further the position and character of different levels taken throughout the country, and which serve to determine the shape of the physical features. The former are obtained by levelling, the latter by contouring.

Levelling means the method of ascertaining the altitudes of any points above the surface of the sea, which is called the "datum level." In England the datum level is that of the mean tide at Liverpool. It is conducted by means of a theodolite, either by taking the angles of elevation or depression from point to point, which necessitates much correction for the curvature of the earth and for refraction, or by the more correct and general method of using the instrument as a spirit-level. Other instruments, which, as their names denote, are merely telescopes capable of being accurately adjusted horizontally, such as the Y level and the "dumpy level," are frequently employed for the same purpose. It is usual to start from one of the "bench marks," that is, one of the points of the greater or lesser triangulation which has been carefully marked on a fixed stone or a building. A levelling rod, which is a telescopic bar made thus for portability, so as to obtain as long a rod as possible with but little inconvenience, and which is graduated in feet and inches, is placed perpendicularly on or close to this point A (Fig. 8), and the theodolite stationed in some convenient position, B, is levelled, the telescope directed on it, and the reading in feet and inches noted down. The rod being now removed to a position, C, higher up the slope, the reading is again taken without removing the theodolite, and the difference between the two observations manifestly shows the difference of level of the two stations fixed by the levelling staff. This, if continued, will ascertain the required altitudes, and is, roughly speaking, the principle of levelling, though there are many minor operations connected with it which serve to correct inaccuracies.

Contours are only shown in maps of very large areas, when an orographic map is alone required to show the relative heights of mountain chains. It would, unless a very large scale is used, tend to encumber the paper with too much detail; but as sections are frequently determined by it, and in some small surveys it is often employed to portray conveniently the shape of the physical features, it will be necessary to examine briefly the method of operation. If we imagine a line to be traced round the coast of a country at its datum level on the sea, a continuous curved line, marking the form of all the features, will be produced. If again we assume the sea to rise to a certain height, and then for a similar line or contour to be made, and so on at regular intervals, a series of curves, finally becoming closed curves more or less concentric, will be obtained, which will at each of these levels delineate completely all the hills and valleys, plateaus, and intricacies of every portion of the country. Contouring consists in tracing out and depicting these lines, and is performed practically by a levelling staff and small theodolite. The latter is stationed at a point whence a view over a large area can be embraced, and the staff is placed at a certain point, the altitude of which has been ascertained previously, and through which it is purposed to make the contour pass. The theodolite carefully levelled is directed on it, and the reading in feet and inches taken, after which the levelling staff is removed to a successive series of points, at each of which it is gradually moved up or down the slope, until the wires in the telescope of the theodolite or level again cut the same height on the staff as they did at the first operation. Manifestly the points on which the staff rested are therefore on the same level, and are marked with small pickets. The positions of these are determined by the chain, and by taking their relative bearings with the theodolite, and the small intervening spaces are sketched so as to complete the contoured line.

Thus the entire delineation of the area, its features, its towns or villages, the direction of its roads, if the map be a topographical one like the Ordnance Survey of the United Kingdom, have all been determined, and by the use of the scale can be transferred to our paper. Even in large atlases but a small portion of this information can be delineated for want of space, and the towns and cities and the river-lines, or mountain chains, can only be given. The amount of information that can be given by a large scale will be more fully referred to in considering the construction of a "plan;" but in the maps of countries such as France or Russia, depicted on scales suitable to ordinary atlases, there are but few noticeable points.

The sides of the map show the number of degrees in the parallels of latitude, for every five degrees generally, the arcs themselves being designated by the numerals, and the intermediate spaces being subdivided into the number of degrees lying between each arc. The top and bottom of the map show in a similar manner the degrees of longitude, and thus by marking the intersection of any of these co-ordinates, the latitude and longitude of given points may be found. Rivers are marked by a single irregular line if small, and by a double line if large, on maps of great dimensions; while the character of the cities is shown by the letters by which their names are expressed. Thus capitals or places of the first rank are marked in Roman characters; towns of the second rank in smaller type, but still vertical lettering; while places of less note are designated in small type with slanting or italic lettering: thus, BERLIN, SMOLENSK, *Salisbury*.

The mountain ranges are represented by fine lines, nearly parallel at first, commencing at the summits of the hills, where they are usually dark, and extending approximately to the plains, where they become lighter and more divergent. These lines are called *hachure* lines, and represent the course that would be taken by rills of water trickling from the summits to the plain. They are invariably used in the larger species of maps, as they interfere but little with the general clearness of the representation.

NOTABLE INVENTIONS AND INVENTORS.

XXVIII.—SIR ISAMBARD BRUNEL.

BY JOHN TIMBS.

THE lives of the two Brunels, father and son, were for more than half a century strikingly identified with the progress and the application of mechanical and engineering science.

The elder Brunel, Isambard Mark, was born in 1769, in Normandy, at Hacqueville, a few miles from Rouen. His parents, who were respectable agriculturists, had four children, of whom Isambard was the eldest. He was intended for the priesthood, but from his earliest boyhood showed a decided inclination for mechanical pursuits; and when at the college of Gisors he would steal away to the village carpenter's shop, and draw faces and plans, and learn to handle mechanical tools; and it is related that one day, seeing a new tool in a cutler's window, he pawned his hat to purchase it. He was next sent to the seminary of Nicaise, at Rouen, where he preferred the study of exact sciences, mathematics, mechanics, and navigation, to the classics. In his play-hours, he loved to watch the quay; and seeing some large iron castings landed from an English ship, he inquired whence they had been brought, and on being told from England, the boy exclaimed, "Ah, when I am a man, I will go and see the country where such grand machines are made." On his return home, though only twelve years of ago, he was already a proficient in turning, in the construction of models—ships, machines, and musical instruments—and is stated to have invented a nightcap-making machine, which is still used by the peasantry in that part of Normandy. He also made an octant, guided by the one belonging to his tutor, and by a treatise on navigation; and at the age of fifteen he took such interest in astronomy as to observe the stars, greatly to the astonishment of the villagers. All this precocity was little gratifying to his father, who would have preferred to see his son in the church or in some merchant's office.

Brunel next passed some time in the family of M. Carpentier, a friend of his father, at Rouen, and went through a regular course of lessons in drawing, perspective, and hydrography. Influenced, probably, by M. Carpentier, who had been a trading captain, Brunel enlisted as a sailor in 1786, from which date up to 1793 he made several voyages to the West Indies. He was remarked for the skill, intelligence, and good humour with which he discharged a seaman's duties. He used instruments of his own construction, and while making a pianoforte, when the ship once lay at Guadaloupe, he also made for himself a quadrant in ebony. His ship having been paid off in 1793, Brunel went to Paris, where he got embroiled in the fury of the Revolution; but he escaped to Rouen, and thence fled to the United States. At New York he joined a party of his countrymen who were about to explore the shores of Lake Ontario to survey the lands of a French company. Brunel led the party of seven persons encamped in the woods, and found a charm in the adventurous work. In 1794 he was appointed, conjointly with one of his fellow-explorers, to survey the canal which now connects Lake Champlain with the river Hudson at Albany. With this work Brunel's career as an engineer may be said to have begun. He next sent in a design for the Houses of Congress, which, though acknowledged as the best, was rejected as too costly and magnificent for simple republicans. He afterwards acted professionally as an architect; and, among other works, built and fitted up the Park Theatre, New York, since burned down. He was appointed chief engineer for New York, and was there employed in the erection of the forts for the defence of the city, and in the establishment of an arsenal and foundry, where his ingenious contrivances for boring cannon and moving large masses of metal with facility showed how successfully he could bring new ideas to bear on the work immediately in progress.

Brunel left New York in January, 1799, and landed in Falmouth in March, where he met Miss Sophia Kingdom, with whom he had become acquainted when in the family of his friend Carpentier at Rouen. This acquaintance, and a desire to work among the scientific engineers of Europe, drew him to England. He married Miss Kingdom shortly after his arrival. He brought with him to England an autographic machine for copying maps, drawings, and written documents; a machine for twisting cotton thread and forming it into balls; and a machine for trimmings and borders for muslins, lawns, and cambrics.

In the accounts of Brunel's inventions, it is stated that the idea of making block pulleys for ships by machinery first occurred to Brunel while he was in New York; but the accuracy of this statement is denied, as we shall presently show. He was employed by Government to carry the plan into execution in the dockyard at Portsmouth. The contrivance comprises, so to speak, sixteen different machines, all driven by the same steam-power, seven of which cut and shape logs of elm or ash into the shells of blocks of any required size, while nine fashion stems of lignum-vitæ into pulleys or sheaves, and form the iron pin, which being inserted, the block is complete. Four men with this machine turn out as many blocks as fourscore did formerly, and at less cost. The supply has never failed, even in time of war, though 1,500 blocks are required in the rigging of a single ship of the line. This machinery, erected by Maudslay in 1804 at Portsmouth, though very complex, in twenty-five years required no repairs. It cost £46,000, and the saving per annum in time of war has been £25,000. A second set of machinery was executed in 1807 for the dockyard at Chatham. There is also a set of magnificent models of this invention in the possession of the Navy Board. The machines work in succession, so as to begin and finish off a two-sheaved block, four inches in length, in the most perfect manner. The entire details of this machinery would far exceed our limits; but the principal parts of which it is composed are clearly described in the first supplement to the *Penny Cyclopædia*.

As to the claim for the invention, when the models were exhibited at South Kensington in 1864, it led to the repetition of the statement that the machinery was invented by Brunel, to which a correspondent of the *Times* replied:—

"Sir Isambard Brunel did not invent, nor did he ever claim to have invented, the block machinery which he had a share in putting up at Portsmouth. The original invention, or series of inventions, was by two men, father and son, each named Walter Taylor, natives of Southampton.

"The beginning was rather more than a century ago" (this was written in 1864), "and was made by the father, who had been at sea, and had been practically impressed with the inefficiency of the blocks in use in his time. After a time they took out a patent for part of their inventions, and subsequently a second patent. These included friction-wheels and circular saws, both of which we owe to the Taylors. During the continuance of their patents, they, under contract, supplied the Government with blocks for the Navy, and for some years they were the only blocks used in the Royal Navy. When, towards the close of the last century, their patents expired, they wished to obtain an extension of them; but the Government objected, and decided for setting up the machinery for themselves.

"Mr. Walter Taylor, the son, who was then making his blocks at the Wood Mills, South Stoneham, near Southampton, generously offered to the Government every facility for the purpose. The Government employed two clever young men to set up the machinery, one of whom was Mr. (afterwards Sir) Isambard Brunel, and the other Lieutenant (afterwards General) Bentham, R.E. With the benefit of Mr. Taylor's explanations, these two young men examined his machinery, and then proceeded to set up machinery on the same principle at Portsmouth.

"Having the resources of Government to back them, they improved the details of the machinery, using for it steam-power instead of water-power, by which Mr. Taylor's mills were worked; but in every essential point the block machinery at Portsmouth is the invention of the Messrs. Taylor. General Bentham's share in the improvements has been forgotten as much as the Messrs. Taylor's original invention.

"Some years ago the specifications of the patents were printed in the *Builder*, and they will enable any one of a mechanical turn of mind, who wishes to ascertain how far Messrs. Brunel and Bentham were indebted to the Messrs. Taylor, to do so easily. The originality of the invention was more than once publicly claimed for the Messrs. Taylor during the lifetime of Sir I. Brunel, and the claim was never contested by him or General Bentham, although General Bentham's widow objected that too little credit had been assigned to her husband."

Mr. Brunel next built in Chatham dockyard the steam sawmill, subsequently improved for cutting veneers, by which double the usual number could be obtained. A popular writer sixty years since describes Brunel's workshops at Battersea, where the solemn action of a steam-engine of sixteen-horse, or eighty-men power, turned by means of bands four wheels fringed with fine saws, two of eighteen feet in diameter, and two of nine feet. Here mahogany and rosewood were sawed into veneers the sixteenth of an inch thick; the same power at once turning these tremendous saws and drawing their work from them. A large sheet of veneer, nine or ten feet long by two feet broad, was thus separated in about ten minutes. The large saws revolved sixty-five times in a minute; hence, 18 × 3·14 × 65 gives 3,672 feet, or two-thirds of a mile, in a minute; whereas, if a sawyer gives thirty strokes of three feet in a minute, it is but ninety feet, or only the fortieth part of the steady force of Brunel's saw.

Brunel next invented a machine for making seamless shoes for the army, which, in regard to subdivision of labour, resembled the manufacture of pins. Every step was effected by machinery; while, as each operation was performed by one hand, so each shoe passed through twenty-five hands, who completed from the hides as supplied by the currier a hundred pairs of well-finished shoes per day. As each man performed but one step in the process, which implied no knowledge of what was done by those who went before or followed him, so the persons employed were not shoemakers, but wounded soldiers, who were able to learn their respective duties in a few hours.

SHIP-BUILDING.—XIV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

THE SKINS OF IRON SHIPS (*concluded*).

THE durability of an iron ship is practically governed by that of the outside plating, which is the part of the structure most liable to deterioration from the oxidising or corrosive action of the sea-water outside, and of the bilge-water within the ship. It will be understood that in making this statement we exclude the wood-work of the decks, inside planking, etc., which may be worn out and replaced many times during the period of service for which the iron hull remains efficient, and no argument will be needed to show the importance of using every possible means to prevent diminution in the thickness of the skin-plates.

The anti-corrosive paint most commonly used on the outer surface of the plates is red-lead, and this is found to answer fairly when renewed at frequent intervals. Other paints and compositions are also employed, most of which are patented; but it is doubtful whether any of them will ever entirely take the place of the cheap red-lead paint. This is also largely used for the protection of the inside of the plating from the upper part of the bilges to the top-sides, where the wash of the bilge-water is not likely to reach when the ship is rolling at sea. Within these limits further protection is required, and is supplied by a thick coating of cement or asphalte, fixed upon the plating, cement being preferred in most cases. Experience has shown that the corrosive action of the bilge-water—arising from the substances it holds in solution, which render it an active chemical agent, or from other causes, such as galvanic action—is most to be dreaded; and many instances might be referred to in which the rivet-heads and the inner surfaces of the plating have been rapidly corroded when left uncovered. Lloyd's rules require all iron merchant ships to be protected below the bilges by cement or asphalte; and they also point out the desirability of so arranging the protecting material as to facilitate the drainage of the bilge-water to the suction-pipes of the pumps. The latter is an important practical matter, as the lodgment of bilge-water in any part of the vessel should always be prevented. To allow the bilge-water to flow readily to the pumps, holes or "water-courses" are cut in the transverse framing, longitudinals, keelsons, etc., and the cement or asphalte is brought just up to the height of these holes. By these means, when well applied, the corrosion and wasting of the plates are practically prevented, cases being on record where the reduction in thickness has not exceeded one-sixteenth of an inch in fifteen or twenty years.

Fouling cannot be so well prevented as corrosion, although very many schemes for its prevention have been proposed and tried. To give some idea of the number of such schemes, it may be stated that between 1861 and 1866 over a hundred patents for anti-fouling compositions were taken out, and during the same interval other compositions were proposed, the preparation of which was kept secret. At present, after all these attempts, the only means of keeping iron ships thoroughly clean is to dock them frequently, to clean or scrape off the growth of marine plants and animals, and to re-coat the bottom with some composition. Fast merchant steamers, such as those of the Peninsular and Oriental Company, are docked and cleaned about once in every six months, in order that no considerable loss of speed may be caused by foulness. Ordinary merchant ships are docked and cleaned about once per annum, the bottoms being coated with red-lead and some protective composition. In the Royal Navy it is customary to dock iron-built ships at least once a year, and to re-coat the bottoms; but the troop-ships employed on active service are docked more frequently. By this means any serious loss of speed can be prevented, when the necessary accommodation is available; but docks are not to be found in all ports to which merchant-ships proceed, or they may not be of sufficient size to receive the ships. And even when this difficulty does not occur, there is the question of expense to be considered, one which is of no small importance. For example, on the Thames the cost of docking, cleaning, and re-coating an iron ship of 1,000 tons gross register tonnage would probably be from £60 to £80, and for larger vessels the expense would, of course, be greater. In distant foreign ports the charges would necessarily be higher; and it might so happen that the vessel had been so long afloat as to render docking a necessity even under these circumstances. But experience proves that the truest economy is to be found in incurring the expense of cleaning an iron ship's bottom, rather than in allowing it to remain foul, and so greatly reduce the speed. There are instances on record in which vessels have been so retarded by foulness as to lose one-third, or even one-half their speed as compared with their performances with clean bottoms; and on a voyage like that from China or Australia, such a loss would far more than counterbalance the expense of docking and cleaning, considerable though it be. One indirect result of this fact is found in the rapid increase in docking accommodation all over the world since iron ships have been in use. Graving or dry docks, floating docks, hydraulic lifts, hauling-up slips, and other plans, have been devised for affording the accommodation required, and there is now consequently a greater chance of preventing iron ships from becoming seriously foul even on distant voyages.

Repeated trials of anti-fouling compositions show that the best of them cannot be considered efficient after more than an average of nine or twelve months' service. These compositions, it should be noticed, are distinct from the anti-corrosive preparations previously referred to, and are put on upon the latter. In the merchant service red-lead is, as we have said, the anti-corrosive paint most generally employed, and it answers very well. In the Royal Navy, either this, or else Hay's anti-corrosive composition, is generally used beneath the anti-fouling preparations. To name the latter would be tedious; to attempt to describe them would be a most hopeless task. Some inventors have based their schemes upon the belief that the barnacles, and other marine animals which attach themselves to the bottoms, should be poisoned by the anti-fouling compositions; but these plans scarcely appear well-founded, seeing that such animals are said to suffer no inconvenience when subjected to the action of the most deadly poisons. Other inventors, deeply impressed with the advantages of copper sheathing as used on wood ships, have attempted to prevent fouling by using preparations containing copper in some form; but here again failure has taken place as regards the prevention of fouling, and the iron hull has sometimes suffered corrosion in consequence of galvanic action resulting from the use of the copper. Another class of proposals consists in the attachment of cement, or glass, or some other material not likely to have any injurious effect upon the iron, to the outer surface of the plating; but these plans have also been found wanting when tried. In short, without saying more respecting the characters of the proposed anti-fouling compositions, it may be stated broadly that up to the present time no sufficient remedy has been found for this serious fault of iron ships. Whether a completely successful anti-fouling preparation will yet be produced it is impossible to say; but if it should so happen, the inventor will undoubtedly confer a great benefit, and should reap a rich reward.

A few remarks respecting the inside planking or plating wrought upon the frames of iron ships must conclude this paper. The general term "ceiling" is applied to all the internal planking, which is commonly connected either to the reversed angle-irons by nut-and-screw bolts, or nailed to pieces of wood (termed "cants") secured to the sides of the frame angle-irons. Between decks in many, but not all cases, the ceiling planks are worked with close-joints, and so form an inner lining. In merchant ships it is also common to have the floors up to the height of the upper part of the bilges completely lined, or "ceiled" over. From this height upwards in the hold-space, the ceiling is sometimes close, and at others only partial, the latter arrangement being known as "batten-and-space" ceiling. Half-round bars of iron are sometimes employed instead of wood planks when the batten-and-space plan is followed. In all these arrangements, however, the main object is to form an inner skin of some kind in the hold, upon which the "dunnage" or the cargo may rest, and to lessen the probability of damage to the skin-plating. There is no idea of adding structural strength, nor is such an addition at all necessary in a well-built ship. One prime consideration to be borne in mind in fitting the ceiling is the provision of means for readily removing the planks in order to ascertain the condition of the skin-plates, and to renew the protecting materials upon them when necessary. Over the parts where the cement is fitted such inspection is especially required; and it is a common practice to fit the ceiling upon the floors of merchant ships in detached pieces, or "hatches" that can be readily lifted. But in other places facilities should be provided for making an inspection of the condition of the hull; and in arranging the structure of an iron ship an endeavour should be made to render access easy to every part, for the purpose of inspecting, cleaning, and painting.

It is only proper to note in passing how great a contrast exists between the facilities for thoroughly ascertaining the condition of an iron ship, and the opportunities afforded for surveying wood ships. When the ceiling is removed from an iron ship, and she is placed in a dry dock with a clear hold, both surfaces of the skin plates are fully exposed, and may be reached by the surveyor. If corrosion has taken place in the plates, or in the frames, it can be readily discovered; if it is at all considerable, the thickness of the worn parts can be at once ascertained by drilling; and in case of need those parts can be removed without much difficulty, and new plates or bars fitted. The heads and points of the rivets are also open to observation, and so the surveyor has complete means of ascertaining the condition of the various pieces and their fastenings. Turning to the wood ship, a very different state of things is met with. Supposing her to be docked, and to have her hold cleared, it is not possible by the strictest examination of the inside and outside to obtain a complete knowledge of her real condition. To do this planks must be removed here and there; the planking and timbers must be "bored" in many places to ascertain whether the wood remains sound; fastenings must be driven out in different parts, as their condition cannot be predicated from the examination of the heads and points, because the middle parts of bolts often waste without any external sign of the decay; and many other devices must be had recourse to if the survey is made thorough. Should repairs become necessary they are often most difficult and expensive. A rotten timber, for instance, can only be replaced with considerable difficulty, and in doing the work it often happens that other defects not previously discovered come to light. In short, the actual state of the iron ship can be ascertained with much less trouble than that of the wood ship, and any repairs needed can be effected with greater ease. These are considerations which should have great weight in judging the relative merits of wood and iron ships, and they greatly influence the commercial success of the two classes of vessels.

Reference has already been made to the fact that many iron ships have inner water-tight skins, forming double bottoms which add both to their strength and safety. The plating of these inner skins is sometimes worked on the in-and-out plan (illustrated by *c*, Fig. 34, page 305), and at others is fitted flush upon the frames. Mr. Scott Russell has adopted the former method in the *Great Eastern*, and other vessels built on his longitudinal system; and an example of the latter will be found in the part section of an iron-clad ship shown by Fig. 23, page 224. When the plating is flush, short edge-strips are fitted between the continuous angle-irons, on the under-side of the plates, so that no liners are required. This method is found to answer very well in practice, and to make water-tight work. It need hardly be said that the butts of the plates in the inner skins are carefully shifted both with regard to each other, and with regard to the butts of the outside plating and longitudinal frames. Carelessness in this particular would obviously lead to a considerable loss of strength, as compared with that attained when proper precautions are taken. In the Government service the diagonal shift of butts (Fig. 36, page 305) is commonly used for the inner bottom, and both edges and butts are single-riveted. This mode of fastening has also been adopted for the inner skins of ships built by Mr. Scott Russell.

In order to make the double bottoms thoroughly efficient as a means of preventing serious damage when the outer plating is penetrated, it is desirable to subdivide the space by numerous water-tight partitions, and to supply water-tight tops. Both these necessities are met in the iron-clads, and have been previously illustrated. As a rule the double bottoms are made to extend up to a few feet above the water-line, and to end at a deck, but this is not always done.

Merchant ships are seldom built with double bottoms, but it is becoming very common to construct tanks for water-ballast in some part of such vessels, and thus what is virtually a "partial double bottom" is often formed. Various plans are followed in building these tanks, but the feature common to most of them is the provision of a water-tight inner skin worked either upon the floors themselves, or else upon longitudinal keelsons fitted upon the floors, this inner skin being by some means brought into water-tight connection with the outer plating of the bottom. With transverse framing it is not an easy matter to ensure this water-tight connection, and to obtain it the frames in wake of the tank are often cut off near the turn of the bilge in order to admit a longitudinal plate-frame which shall form the side boundary of the tank. This frame has angle-irons on both edges, and is riveted to both skins, the caulking of the two joints being readily performed. Another plan consists in scoring the inner skin out between the transverse frames near the bilges, and riveting its edge to the outside plating; but this involves considerable difficulty in securing water-tightness at the junctions of the inner plating and the frames. The economical value of water-ballast, however, is so great as to override these questions of practical difficulty and expense. Ships so built can, by the admission of water into the tanks when without cargo, be brought to the proper trim; and the water can be pumped out speedily when required. Time and money are thus saved to a very considerable extent, and it is no wonder that ship-builders provide this simple means of avoiding all necessity for using rubble-ballast, on the old plan. The use of water-ballast began, we believe, in the iron screw colliers trading from the Tyne, and it has already been the source of enormous savings. If ship-builders were, however, to push their reforms somewhat further, adopting improved methods of framing, and complete double bottoms, they might, without sacrificing any of these advantages, produce stronger and safer ships.

SANITARY ENGINEERING.—XXI.

HOUSE DRAINAGE.

PASSING on from the subject of our last two papers, closets and traps—*i.e.*, the mechanical appliances for what we may call the internal sanitary engineering of a house as contrasted with the external—we now come to the provisions requisite for removing sewage and waste water of different descriptions in the most efficient manner; and here we have to deal with many incidental circumstances arising from locality, the facilities of the neighbourhood, and other different causes. The method of external drainage for a town house, which has nothing to deal with but its own water-supply and sewerage, and of a country mansion in a district where no general sewage system exists, must necessarily differ in detail, although some few broad general principles will apply in each case.

Thirty years ago no general system of drainage was in existence, and cesspools were in very constant and general use even in London, and to this day in many courts and back-ways they are still in existence, though when discovered by the sanitary inspectors they are speedily done away with, and the modern system of pipe-drainage compulsorily introduced, as required by the Sewers' Act. As a matter of antiquarian curiosity, it may be interesting to remark that in sinking for unusually deep foundations in the City and elsewhere, it sometimes happens that old cesspools are opened of which the lining or walls (steining is the technical name) was done with the horns of animals curiously bonded together, forming a receptacle for the solid soil, but allowing the liquid manure to soak and drain away into the surrounding ground; these are probably of very early date.

In the time of the Romans chalk was used for a similar purpose built up dry in irregular lumps, and within the last few months two cesspools were discovered in the excavation for the foundation of a new building on Ludgate Hill. The late practice was to use bricks laid dry without mortar in a similar way, and old disused cesspools of this class are often turning up. In all urban districts or metropolitan centres the cesspool system has long been abandoned, and the general system of sewage bears the burden of all inhabited houses within a given area; but in some suburban districts, and in all country situations where there is no adjacent river or brook to receive the sewage, or in point of fact to act as a sewer, the necessity of the case compels the adoption of the cesspool system, and of this, therefore, with the various modifications and the necessary hygienic details, we must give some account. To return, however, to our subject proper—the details of house drainage. Some years ago an idea was prevalent that pipes of three inches diameter of glazed stone-ware would be sufficient to convey the drainage of an ordinary dwelling-house; but experience has proved that, though theoretically large enough, the constant stoppages arising from adventitious causes—a rag, a piece of newspaper, a gradual accumulation of grease from kitchen waste—required such constant attention that these small sizes of pipes have been long ago abandoned, and we may state that the sizes now practically in use are six inches diameter for a small house, and nine or twelve inches for a large house or a mansion. Where there is a general system of sewerage, these pipes should be conducted to the common sewer in the street or road, as much fall as possible being obtained as is compatible with the level of the ground or the nature of the situation. Two inches in the length of ten feet may be taken as an absolute minimum, as in cases where this fall is not obtainable it is better to adopt some independent mechanical method of dealing with the sewage or drainage. As an instance of the way in which exceptional cases may arise, we may mention the case of the London and Westminster Bank in Lothbury. On making some recent addition to this building, owing to the exceptional nature of the ground, a bog situate on the exact line of the old Walbrook, it was necessary that the ground should be excavated to a depth considerably below any of the adjacent sewers; there was no influx of drainage proper, but a considerable amount of subsoil water to be dealt with; a small well or sump was formed for its reception, and it is periodically removed by pumping into an adjoining sewer.

The glazed drain-pipes now universally in use are comparatively a modern invention. Into the detail of their manufacture we do not now propose to go, as that will form the subject of other series of papers in THE TECHNICAL EDUCATOR, but only to explain the precautions to be adopted in their use, and the various modification of constructions of detail required for efficient house-drainage.

There are various descriptions of pipes manufactured from different materials in different districts, all equally efficient. but each possessing some peculiar characteristics. In Staffordshire they are burnt from a species of fire-clay, and are dark in colour, similar in material to what are called Staffordshire bricks; in London they are burnt from clay obtained from various parts of the country with a large admixture of broken pottery finely ground and sifted for the better kind of work; while in Kent, in the neighbourhood of Aylesford, the Gault clay is the principal ingredient, and a pipe of lightish colour and very tough consistency is the result. The same patterns, however, apply very much throughout, and it is with the detail of these that we have now to deal. When first introduced they were about 2 feet in length, the joint being made by a plain socket, as shown in the sketch above (Fig. 36).

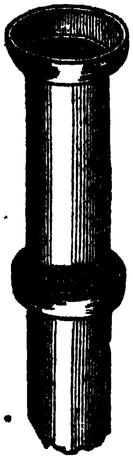


Fig. 36.

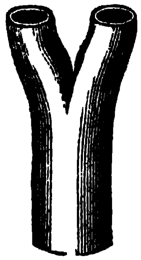
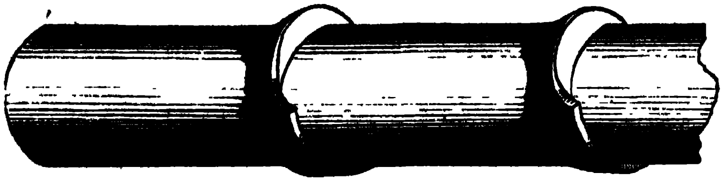


Fig. 45.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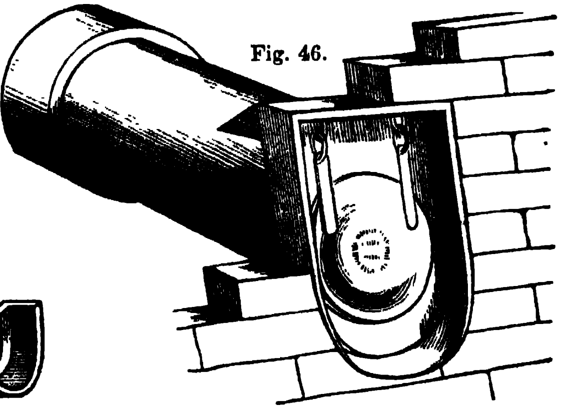
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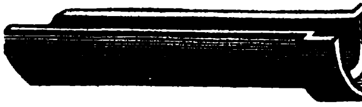


Fig. 38.

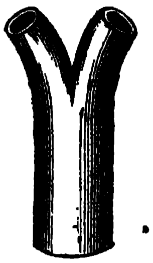


Fig. 44.

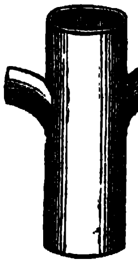


Fig. 43.

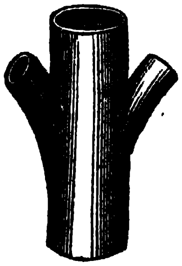


Fig. 42.

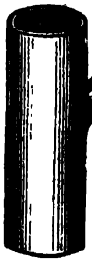


Fig. 40.

Fig. 41.

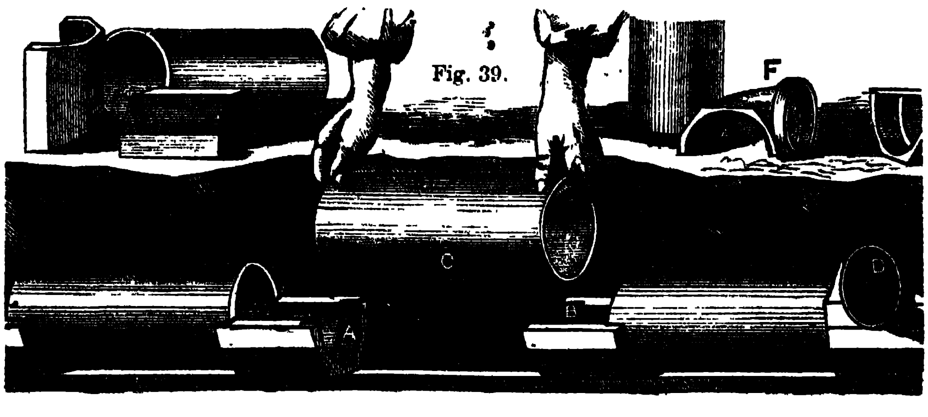


Fig. 39.

It is evident that where long length of pipes are laid upon this system, the only method of opening them for examination was to break one or more of the pipes, and when the repair was made a patch with tiles and cement was the result, running risk first of leaking, and then of an obstruction of the inside of the pipe by the falling in of a portion of the material, or the running out of the cement while the joint was being made, which subsequently would harden into a permanent obstruction. To get over these difficulties various plans were introduced. Our next sketch shows a method in which the upper lip, as we may call it, of the socket is absent, which allows a single length to be removed and another dropped into its place: this presents some advantages (Fig. 37).

Another method is to manufacture the drain-pipe in two halves longitudinally, the upper half removable, the lower half remaining undisturbed while the drain is examined and cleared out. The sketch (Fig. 38) shows the construction.

Another more complicated but probably more efficient plan is shown below in Fig. 39, which also indicates the exact method of laying the pipes and the introduction of junctions.

There are various other inventions of similar character, but we have only instanced a sufficient number to show what facilities exist for ready access to a system of pipes for examination and cleaning.

In the erection of new buildings it is not desirable that the drain-pipes should be laid when the work is first commenced, for although the plan promises certain advantages in keeping the basements dry during the progress of the work, it is found in practice that the settlements which almost invariably take place in new work very often break the pipes where they pass through or under the walls; the subsidence or sinking of the ground from various causes sometimes produces the same result. It is therefore recommended that the carcase of the building should be first completed, and that the carrying out of the drainage should be deferred until the latest period at which it will not interfere with the floor-laying and finishing of the interior.

The junctions of pipes now claim our attention, and we give some illustrations of the "junctions," as they are called, which are made ready burnt for that purpose.

Figs. 40, 41 represent the junction *single* of a smaller pipe with a larger one at different angles, and we have to call attention to the point that the direction of the junction at its angle should always be the same as that of the fall or current of the larger pipe, as if this is not attended to, and the entry is made in the contrary direction, obstruction will sooner or later result. We show in Figs. 42, 43, 44, 45 four different kinds of double junctions to which the same remarks apply. The ventilation of these drains is a very important matter now only beginning to occupy a leading share of public attention, as also the disinfection of the sewage gases arising in them; but with these points we shall deal at length in a subsequent paper. One point now remains to be alluded to—the entry of the drains into the sewer, where a sewer is in existence; this should always, if the level permits, be above what we may call the central axis, and for this reason, that if by accident the sewer should be flooded (and our late experience of metropolitan main drainage shows that even now such an event is far from uncommon, especially, as may we say, in the Farringdon Street district), all the lower end of the house-drain is filled by the back pressure of the water, and as long as the obstruction in the main-drain lasts becomes, as it has been called, an elongated cesspool; whereas if the entry is made well up towards the topmost level of the sewer, this difficulty is very materially obviated.

In many districts, metropolitan and otherwise, the sewers are waterlocked, as it is called, for twelve hours at least out of the twenty-four, and then some precaution like that indicated in Fig. 46 becomes most desirable—a stone-ware pipe provided at its junction to the sewer with a galvanised iron flap which closes as the tide rises. This is called a *tide-valve:* it opens the moment the tide falls at the slightest pressure of water from within; this prevents all back-water flowing up into the sewers or basement of the house, while it allows a facile exit for all the daily requirements at proper times of the tide.

Thus far we have dealt with the technical detail of "house drainage" in localities where a complete system of public sewers is in existence. We must now give some attention to localities where there is no such provision, and where, therefore, the introduction of a sump or cesspool becomes an absolute necessity; and here, taking the case of a large mansion or asylum situated in an isolated part of the country, we have various elements to consider. There is (1) the surface water; (2) the subsoil water; (3) the water-supply from well or otherwise; (4) the rainfall—various at different times of the year; (5) the sewage proper from closets, kitchens, stables, and elsewhere. The rain-water is sometimes separately dealt with and stored in a tank by itself. On sandy or gravelly soils not in a low district, the subsoil and surface-water may be left to take care of itself and make its way through the ground; but on heavy, low-lying clay lands this cannot be done, and therefore proper provision must be made for its disposal; and we may take this as a first axiom, that the cesspool, whatever its size—and for a large asylum it should be about as large as the dining-room—should be situated as far away from the inhabited portion of the buildings as possible, and should be made water-tight, providing at the same time ample means of ventilation from its upper levels; if this is not done, the sewage gases will find their way up the pipes, and, if these are not efficiently ventilated, into the living-rooms, with the certain result of general discomfort and unhealthiness, and in bad cases even of typhoid fever. If there is an available overflow, the waste sewage water may be advantageously distributed over the land; if not, mechanical means must be adopted to empty the receptacle at stated times.

In porous or open soils it may be advisable to have the pipes pervious, so as to allow the drainage water to percolate away through the surrounding land; and where, as in shingly soils adjoining the sea, the tide rises, no deleterious results will follow. But in retentive soils the result will be the saturation of the surrounding ground with sewage matter. In every case, however, local circumstances must dictate the course to be taken, and it is impossible to prescribe one uniform course for every locality.

Before the present generation these questions hardly arose, as the ordinary method of house-drainage was by the old-fashioned barrel-drain, as it was called, a simple tube of brickwork in mortar of various sizes from 9 inches upwards, built round a wooden centre which the workmen removed forward from length to length as the drain was built; while in some isolated districts common red pottery pipes were used mostly without sockets. In these cases the ventilation was provided for almost completely by the natural circumstances—the crevices existing in ordinary brickwork, and the butt-joints of the pipes, allowing a free escape for the sewer gases; while the larger size of the drains, never less than 9 inches for house purposes, left a very considerable air-space. Except, however, in cases of very rapid fall the amount of sewerage deposit in these old-fashioned drains was always considerable, and one important point to be attended to on entering upon a new property was to have the drains opened and cleaned out, a disagreeable and sometimes unhealthy process, which, however, it was absolutely necessary to repeat at intervals of a few years. Where a modern system of pipe-drainage is judiciously laid with proper points of access, the drains, if not entirely self-cleansing, as they may generally be made by the adoption of some of the systems of flushing described in our previous paper on "Economy of Water-supply," can be cleaned out and kept in a satisfactory state with comparatively little trouble or annoyance.

Since public attention has been so prominently directed to the subject, several new inventions have been introduced for the ventilation of house-drains, and of this subject we shall treat at some length in our next paper.

CAPITAL AND LABOUR.—I.

By J. E. Thorold Rogers, M.A., Tooke Professor of Economic Science.

THE SUBJECT IN GENERAL.

In the whole range of subjects with which political economy or social science has to deal, none is nearly so important as the relations which subsist between what are called capital and labour. At the present time the questions which arise on these relations are in the highest degree vast, difficult, and menacing. Attempts have been made from time to time to construct a society within society, in which an experiment can be made, for the purpose of substituting a new organisation for that with which we and our forefathers have been familiar since the earliest memories of civilised society. Such expedients, known by the general names of communism and socialism, have been advocated not only in France, Germany, and England, where the density of population, and the consequent pressure of poverty, lead to the ventilation of schemes for the reconstruction of society, but in the United States, where there is abundant space for all kinds of industry, and where, in consequence, those social problems which agitate an old and fully peopled country do not yet, and will not for a long time, be prominent enough to demand a solution.

Latterly, however, the movement has assumed proportions of far greater magnitude. Trade between nations, and the facilities of intercourse with which science has assisted trade, are making and will make the municipal boundaries which separate nations mere geographical expressions, which are easily passed. Modern communities are getting ideas from each other. A few years ago, the man who travelled over Europe was a mere exception. A few years ago the chief intercourse between nations were the diplomatic communications which governments instituted and maintained Now the habit of travel is becoming general. It is rapidly influencing the artisan classes. Society, long immovable, is beginning to transfer itself from place to place. Nay, we are informed that labour has an organisation throughout the civilised world, which is rapidly being consolidated, which has its agents in every great town, and which, under the name of the International Society, is powerful already, and is likely to become more so. In all these attempts, partial and general, to change the foundations of society, there is a struggle between capital and labour, between profit and wages, between the employer and the workmen, between property and industry. I purpose in these papers to attempt an explanation of these several social forces.

Ask any economist, and he will tell you that capital is the accumulation of past labour, intended to move or assist labour, and that it is either a transient or a permanent assistance, the former requiring constant renovation, the latter being of an enduring character. Ask him what labour is, and he will tell you that it is the power which intelligence gives man over the properties of matter and life, by which muscular effort can make matter useful. It will be added that this power which the labourer is able to exercise over matter may be either the direct action of the man, or may be indirectly exhibited upon certain inorganic and organic powers; in other words, that the workman may be plying his own muscles, or may be guiding animal power, or be using steam, wind, or any other natural motion which man is able to control and direct for his own ends. In technical language economists speak of fixed and circulating capital, of muscular and nervous labour.

All these definitions and distinctions, however, are not fundamental, but only denote tendencies under which the same facts appear in different forms, or in which one of the circumstances which accompanies the fact is exhibited in different degrees of intensity. Thus the labour of a manager is said to be nervous, that of a workman muscular. But unintelligent effort is of no avail, even for the commonest acts, nor can the sharpest intelligence give effect to its thoughts, except by means of muscular effort. No labour appears to be more characteristic of the brain than the thoughts of a poet or musician are, but both these personages must at least exercise the mechanical function of writing or speaking.

Again, it is true that capital is the accumulation of past labour, embodied or condensed in material objects. With one exception—viz., land available for occupation or cultivation in densely-peopled countries—there is no object whatever, which possesses value, that has not obtained its value, by reason that labour has been expended on it. A sack of wheat, a bale of cotton, a barrel of wine, a wedge of gold, a house, a spinning-machine, possess whatever value the market assigns to them by reason that labour has been expended on their production. It signifies nothing, from this point of view, whether the article is movable or has been gifted with qualities which cannot be recovered or resumed in their original form. In every case, it is labour, and labour only, which confers on these objects those properties which economists recognise and comment on.

Unless we acknowledge this fact, we shall find it impossible to discern satisfactorily what are the relations of capital and labour, of the employer and the workman. If we acknowledge them, we shall, though not without some trouble, discover the key to these social questions, which, as I have already stated, are of such pressing and universal interest. For we shall discern that the production of labour is just as much an investment of labour, and therefore just as much an exhibition of capital, as any of these objects are to which reference has been made above. A man who brings up children, and renders them fit for those various forms of industry to which human capacity is fitted, is just as fully investing capital in them, as if he were building houses, or constructing machines, or collecting agricultural crops. It is only because his domestic relations to such children are the prominent features in their connection with him, that the position in which the education of labour stands to the general energies of society is misapprehended or ignored.

If we would see what is the significance of this production of labour to the general well-being of society, and observe how exactly it corresponds to any other investment of capital, we may consider an hypothisis, which could not happily become an actual fact, but may be contemplated as an abstract possibility, and has been, unfortunately, verified at one epoch in the history of civilisation. We can imagine that the transmission of that which an existing generation knows may be withheld from a growing generation, that the additions which are being made to the present stock of human knowledge or skill were arrested, and that what is known is not communicated. Such a state of things, it may be imagined, could occur suddenly. It has, as I have said, occurred gradually at one period in the history of mankind, for Europe in the tenth century of our era had lost nearly all the arts, and almost entirely the culture, which existed at the commencement of that era. The consequence of such a sudden cessation in the function of communicating the knowledge and skill of one generation to its successor, would be a rapid or gradual relapse into barbarism. Such a reverse would be of incomparably greater significance than any diminution in any other kind of wealth, and would be followed by infinitely more disastrous results. The maintenance and education of children is therefore a far more important investment of capital, a far more significant object of labour, than any other accumulation. It seems not to be so, only because under certain circumstances there are more men to work than there is work for them to do. To some extent this occurs in the case of other accumulations; for there may be more wealth accumulated than there are objects on which such accumulation can be advantageously employed. Quantities, however, of unemployed labour diminish the portion of general wealth which labourers can individually appropriate; quantities of unemployed wealth in other objects increase the power by which labour can be called into activity.

Capital, then, and labour available for industrial objects, and which is also in demand for industrial agencies, are only two forms of the same fact; both are accumulations of labour. There is no labourer who does not possess in himself an investment of capital; there is no capitalist who does not represent an active industry, if he be an employer of labour, and superintends the labour which he employs. The struggle which arises from time to time between the employer and the labourer, is a struggle between two forms of the same fact, between two forms of labour, each of which is seeking to appropriate more of that common produce which is shared between the labourers on the one hand and the employers on the other. In social science there is no struggle between diverse forces, rivalry existing only in similar forces. Hence if the function performed by the capitalist and that fulfilled by the labourer are united in the same person, not only is the quarrel necessarily at an end, but the maximum of productiveness is attainable at the minimum of cost or loss. In the course of these papers we shall see what are the phenomena of that state in which this harmony is effected. Until it is effected there is no means by which an adjudication can be made on these rival interests, except it be that of the barbarous expedient of strike and lock-out, or the temporary settlement of arbitration.

POSITION OF THE QUESTION IN ENGLAND.

In foreign countries, especially in France and Germany, the relations of labour and capital have been debated from that point of view which contemplates the reconstruction of society. These two countries have been the homes of those socialist or communist movements which aim at altering human life and action from its very foundations. These projects are futile, for civilisation, imperfectly as it may have been realised, is a true growth which cannot be made different from what it has become by means of any external influence. It is true that the advocacy of these expedients has made men restless, discontented, turbulent, and sometimes violent, but no success has ever followed on the efforts which have been made after such fundamental changes.

There is a reason, however, why these projects have been developed in these countries. In both the unity of the nation has been effected only after great toil, and by a government which has been almost despotic. Now, in such a state of society, the right of individual action or of combination is very sparingly accorded. The policy of a government in such a country tends always towards doing as much as it can, and of discouraging independent action on the part of its subjects. The administration is centralised, as people say. Hence the people learn to depend on government to give them a start, and refer to government when they are at a loss or in a difficulty. Now it is only a step from this state of mind to that other in which government does not merely regulate action, but takes upon itself the business of originating action. Under these circumstances a people begins to believe that government is a power which can and ought to confer great benefits on the people, which can assist them in a thousand ways, which can finally not only correct what is wrong in the laws or customs of society, but can do what is expedient, right, and charitable. But if the government can do so much good, why not, it is argued, undertake the development of that benevolent scheme which, in the dreams of some enthusiast, will remove all that is evil from the world, and produce all the good? Human life is full of misery and poverty: it is the business of those who govern human affairs to find a remedy for these disorders.

PRACTICAL APPLICATION OF THE FINE ARTS.—XII.

THE ART OF MOSAIC (*continued*).

By P. H. DELAMOTTE, Professor of Drawing, King's College, London.

WE give in the present paper some representations of mosaics, that have been, or are being executed by Simpson and Son of London. We had hoped to give these in colours, but as this could not be accomplished, we must do the best we can with the woodcuts. In speaking of woodcuts, however, we may here remark, that in many of those given in previous numbers, among which we may reckon all those from Cirencester, the exact number and shape of the tesseræ have been preserved, the original pavements having been traced, and the tracing diminished by photography to the required size of the woodcut. But in spite of this, coloured illustrations would give far more clearly the style of work produced by English workmen in the present day.

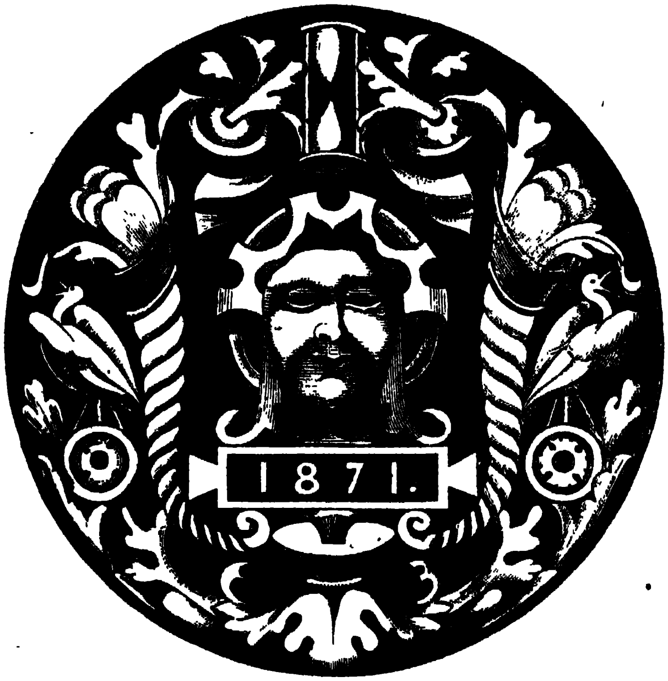


Fig. 30.—MOSAIC REPRESENTING ONE OF THE SEASONS.

We may be permitted to refer here to a life-size mosaic of Hogarth, intended for the South Kensington Museum. The likeness is naturally taken from the well-known portraits of the great father of the essentially English school of painting. We are glad, independently of the value of the mosaic, thus to point out a portrait of a man to whom English art owes so much. We look upon it that to Hogarth, even if he was not a painter of the highest class, nor a man of transcendent talent, English art, and so the whole range of national art, owes a deep debt of gratitude. By his determined protest against the trammels of foreign taste; by the violation, on the part of a man who had genuine thought and true enthusiasm in him, of the rules laid down for other times and other countries, he showed that each nation has peculiarities of taste and disposition that develop themselves in the arts of that country, if they are allowed legitimate play; that the artistic taste and feeling of one race cannot be violently transported into another; that the attempt to do this merely produces a race of copyists, with all the vices and the weaknesses of copyists; whilst each nation can alone develop and enlarge its own characteristic art, grafting in, it may be, from time to time some of the excellences perceivable in the arts of other races, but in the main keeping to the old lines. These remarks we do not confine to any one branch of that circle of human endeavours which we entitle fine art; but if it is, as we contend, entirely true of some, it must be true of all, and it will be impossible for some of the arts to rise from their present degraded condition in England until this position is truly recognised; and that as the politics of to-day take their root in, and form part of the whole history of this country, as far back as the mind of man can trace, so the arts of England must trace back their origin to the early and rude attempts of our ancestors, must develop the lines that these suggest, and add thereto whatever grace and beauty can be acquired first from nations kindred in blood and in taste, and next from the universal canon of taste which appeals to our common humanity. A wise artist is like unto a man that is a householder, who bringeth forth out of his treasures things new and old.

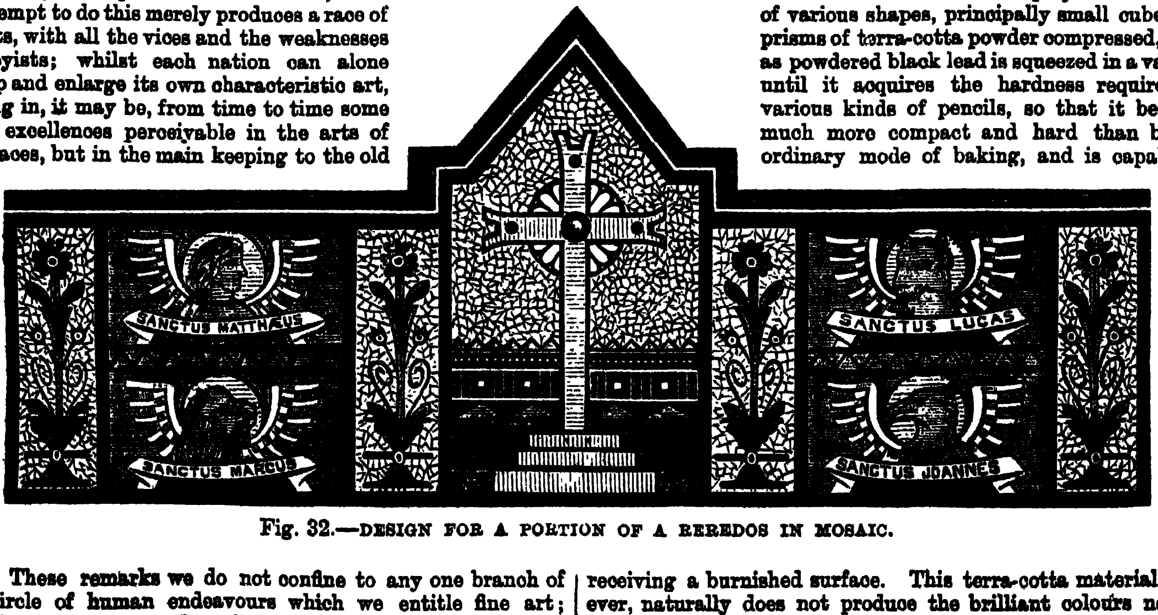


Fig. 32.—DESIGN FOR A PORTION OF A REREDOS IN MOSAIC.

But to return to the mosaic of Hogarth. The attitude is one of comparative repose, and thus fulfils the conditions we indicated when in a former number we recommended the study of the figures at Ravenna. The characteristics of the man himself, as he himself introduced them, his palette, the comic mask, and his dog, find natural places. The position is easy, and is that of a man contemplating his subject preparatory to active work which he may momentarily begin. This combined effect of a position that we are not surprised to see continued, and at the same time naturally leads to active motion, is highly suited for this material. It should partake somewhat of the calm character of sculpture, and yet the gold background so entirely throws the figure into relief, that we should almost anticipate motion.

The style of colouring is well adapted also to the material. We are not now dealing with the glass mosaic of Venice, for which Messrs. Salviati and Co. are so celebrated; nor with the Comati work from the Pope's workshop in Rome, in which various materials are employed; nor the *opus vermiculatum*, of which Florentine work is the modern representation; but with purely English terra-cotta work which has even been called *opus Anglicanum*. The materials employed are tesseræ of various shapes, principally small cubes and prisms of terra-cotta powder compressed, much as powdered black lead is squeezed in a vacuum until it acquires the hardness required for various kinds of pencils, so that it becomes much more compact and hard than by the ordinary mode of baking, and is capable of receiving a burnished surface. This terra-cotta material, however, naturally does not produce the brilliant colours nor the bright effects of glass; it would consequently be absurd to attempt the same style of colouring as may suit an Italian sky and a vitreous material. And this is a great advantage, especially since other causes have contributed so much towards fostering a taste for a heavy, crude, and over-loaded tone of colouring both in our pictures and our manufactures. Rather dull colours harmoniously disposed, therefore, are suitable to most subjects, and contrast all the more vividly with the bright-

and flat, yet varied, golden background. The necessity for making the terra-cotta tesseræ in moulds, confines the shapes to only a few varieties of surface—squares, rectangles, and triangles of various forms complete the category. It is impossible, therefore, to produce the irregularity either of the old Roman pavements or of modern glass mosaic. This has its advantages and its disadvantages. Among the latter may be esteemed a certain flatness originating from the formality of shape, and the non-appearance of the cement between the interstices of tesseræ, though in this respect the modern glass mosaicists also lose a strong element of beauty, and throw away one of their advantages, by using cement coloured to match their materials. But as a compensating advantage the terra-cotta worker has a wider range of shades, since the blocks being far smaller than the *smalti* are ever broken into, the gradations of colour and shade are better preserved. In order, too, to counteract the flatness of the regular divisions, the English workman breaks up his gold, which, of course, consists of *smalti*, into irregular portions, thus causing a very different effect from the more regularly divided gold backgrounds of the Italians.

In such pieces of workmanship as the portrait of Hogarth, there are, of course, a great many degrees of difficulty and of excellence in the mere work. The flat backgrounds require but little skill to match the pieces to the most convenient forms. The outlines of clothes, the matching of tints, and the drawing of the coarser parts require more delicacy and taste, whilst the hands and heads demand the skill of a regularly trained artistic workman. A very large proportion of the work done at South Kensington and at other manufactories of mosaic is executed by women, and this is a branch of labour well suited to their capacities, since it is rather neatness and taste than bodily strength that is required.

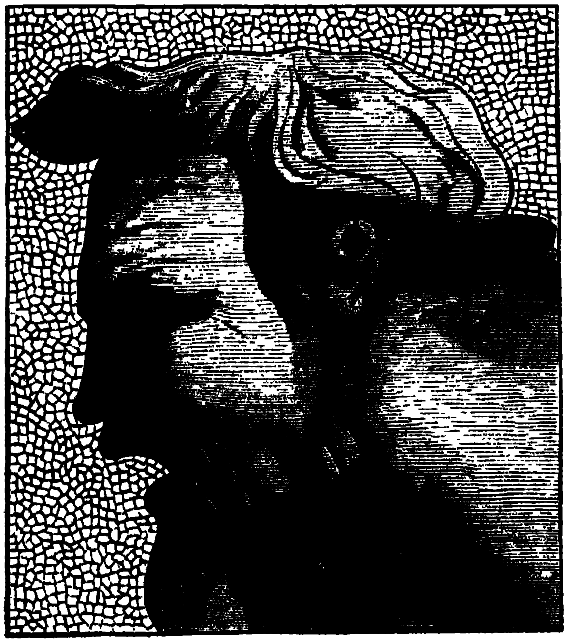


Fig. 31.—HEAD OF THE PROPHET ISAIAH, DESIGNED FOR ST. PAUL'S CATHEDRAL.

We give in the preceding page (Fig. 30) a medallion, one of four on a screen, intended to represent the seasons, a subject common enough amongst the ancients, as we have noticed before. In this case, though only three colours are used, several tints are required to produce the shadows, and to throw up the forms. Fig. 31 is intended for a head of the prophet Isaiah, and is taken from a design by Mr. Alfred Stevens for a pendentive in St. Paul's Cathedral. It is well that the cathedral church in the metropolis should receive the best we can give it in the form of an offering from Art; and it is to be hoped that the effort now being made to decorate the interior in a manner worthy of the original design may be as successful as it deserves to be. The completion of a great work like this must lead to a more elevated taste among the many who day by day have this object presented to their view. Recent improvements in London have led to many openings through which the great cathedral can assume its proper proportions; and it would be sad that after the mind had been prepared by these distant views, and by a closer admiration of the colossal size of the structure, that all enthusiasm should be baulked by a bald and cold interior. We hope, therefore, that something may be done worthy of the great building itself; worthy of the city over which it presides; and worthy of the nation of which it is, from a civil if not from an ecclesiastical point of view, the principal church. The design before us is worthy of such a building. Bold and massive in its treatment, it is suitable for contemplation at a distance: we may, therefore, be sure that it will be worked out in a forcible manner, with tesseræ of considerable size, and shades plainly delineated. We trust to such work as this to elevate both artist and workman, and to prepare the way for further advances on the same road.

Fig. 32 is intended to represent a portion of a reredos for a parish church. The ordinary emblems of the Evangelists have their names beneath them. These stand out from a dull background; but in a still more striking manner does the central emblem of the cross in pure white arise from a background of gold. The intervening spaces are filled with conventionalised flowers. The effect of good mosaic with a large admixture of gold in it in lighting up and enlivening our churches, generally either devoid of colour, or else relying on paint and hangings for the tone that should be obtained from the structural materials, ought to be studied by all those who are anxious to help on the progress that architecture has been making for many years, and which we hope it will long continue to make. As we said at first, mosaic is an architectural art, and unless it subserves the main purposes of a building, it is not likely to gain a permanent hold on the taste and feelings of the nation. We hope to see the day when amongst the English who are true lovers of the real, the solid, and the permanent, mosaic may find a place as much its due, and as consonant with our feelings, as it was with those of the Romans of old, when a man of taste and property felt that his house was not properly finished, nor his furniture fitly decorated, unless they were alike adorned with mosaics of the highest order of merit.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XIV.

BY E. WYNDHAM TARN, M.A.

SMITH'S WORK AND BELL HANGING.

THE smith's work in a building includes all heavy materials of cast or wrought iron, as furnace and chimney bars, girders, columns, iron joists, heads to king and queen posts, tie-rods and bolts, newels, brackets, cantalivers, rain-water pipes and gutters, iron railings, guard bars, cramps, cisterns, tanks, furnace and soot doors, grates, stoves, ranges, stable fittings, iron roofs, etc. Most of the smith's work is taken by weight, even where it has to be measured, the sizes of the articles being entered in the dimension book, and afterwards brought into lbs., cwts., or tons by means of a table of the weight of iron of given breadth and thickness. Articles in cast iron that require a pattern to be made expressly for them must be taken by weight, and the patterns numbered separately; but for articles in common use, or where a large number of the same pattern is required, the pattern is not charged. All labour in filing and fitting cast-iron work must be taken by the foot-run. Measure the length of cast-iron columns or cylinders, and enter it in the dimension book, stating the diameter externally, and also internally if hollow; the weight per foot-run can then be ascertained by help of the following

TABLE OF WEIGHT OF SOLID ROUND CAST-IRON COLUMNS PER FOOT-RUN.

DIAM.	WT.	DIAM.	WT.	DIAM.	WT.	DIAM.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
1	2½	2½	15⅓	4	39¼	5½	74¼
1½	5½	3	22	4½	49⅔	6	88⅓
2	9¾	3½	30	5	61⅓	7	120¼

To find the weight of a hollow column or cylinder by means of this table, deduct the weight of a solid column having the given internal diameter from that of a column having the given external diameter. Thus the weight per foot of a hollow column 6 inches outside diameter, and 5 inches inside, or with ½-inch metal, is 88⅓ less 61⅓, or 27 lb.

The weight of cast-iron girders may be found by taking each part separately—namely, the top and bottom flanges and the web, giving the width and thickness of each, and finding their weight from the following

TABLE OF WEIGHT OF FLAT CAST IRON, 1 INCH WIDE, PER FOOT-RUN.

THICKNSS.	WT.	THICKNSS.	WT.	THICKNSS.	WT.	THICKNSS.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
¼	⅘	1	3⅛	2	6¼	3½	11
½	1½	1¼	3⅞	2½	7¾	4	12½
¾	2⅓	1½	4¾	3	9⅓	5	15⅔

For example, to find the weight per foot-run of a cast-iron girder with parallel flanges, the flanges being 10″ × 2″ and 3″ × 1½″, and the web 12″ × 1¼″; 10″ × 2″ weighs 10 × 6¼, or 62½ lb.; 3″ × 1½″ weighs 3 × 4¾, or 14¼ lb.; 12″ × 1¼″ weighs 12 × 3⅞, or 46½ lb.; and by adding these weights together, we find that of the girder to be 62½ + 14¼ + 46½ = 123¼ lb. per lineal foot.

The weight of cast-iron stanchions, storey-posts, etc., can be also found by help of this table. The weight of flat plates of cast iron can be found by means of the following

TABLE OF WEIGHT OF FLAT CAST-IRON PLATES PER FOOT SUPERFICIAL.

THICKNESS.	⅛″	¼″	⅜″	½″	⅝″	¾″	⅞″	1″
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
	4⅔	9⅓	14	18¾	23½	28⅛	32⅞	37½

Cast-iron rain-water pipes, and eaves gutters are taken by the yard-run, every fraction of a yard being taken as a full yard; the heads, shoes, nozzles, angles, sockets, bends, T and L pieces, etc., are numbered. The size and pattern of the gutters and pipes must be described, and whether galvanised. Cast-iron balconies, and other railings, are often taken by the foot-run, describing the height and character of design. Cast-iron copings are taken by the foot-run; coal-plates, scrapers, bell-traps, pumps, etc., are numbered according to size. Stoves for open fireplaces are valued at per inch width of frontage, and according to quality; it is common, however, to state the value per stove. Ranges and kitcheners are also valued according to the width of opening, and numbered in the bill. Cast-iron frames and doors for furnaces are taken by the pound weight.

The iron ramps, sills, posts, mangers, troughs, etc., for stable fittings are generally numbered; the cast-iron channel guttering being taken by the foot-run. Cast-iron gratings are taken by weight, which can be determined by the foregoing tables; small gratings, as air-bricks, etc., are generally numbered.

Wrought iron, when used in large quantities or dimensions, is taken by weight, the length being entered in the dimension book, describing diameter, width, or thickness, as the case may be. The weight per foot-run of round wrought iron can be found by the following

TABLE OF WEIGHT OF ROUND WROUGHT IRON PER FOOT-RUN.

DIAM.	WT.	DIAM.	WT.	DIAM.	WT.	DIAM.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
¼	⅕	1	3⅓	2	13½	3½	41⅙
½	⅞	1¼	5¼	2½	21	4	53¾
¾	1⅞	1½	7½	3	30¼	5	84

The weight of wrought-iron girders, joists, flat bars, etc., can be found by taking separately the different thicknesses, the weight of which per foot-run is given by the following

TABLE OF WEIGHT OF FLAT WROUGHT IRON, 1 INCH WIDE, PER FOOT-RUN.

THICKNESS.	WT.	THICKNESS.	WT.	THICKNESS.	WT.	THICKNESS.	WT.
in.	lb.	in.	lb.	in.	lb.	in.	lb.
[illegible]	⅖	¾	2½	2	6¾	3½	11¾
[illegible]	⅞	1	3⅜	2½	8½	4	13½
[illegible]	1⅔	1½	5	3	10⅛	5	17

The weight of flat plates of wrought iron of various thicknesses can be found by means of the following

TABLE OF WEIGHT OF FLAT WROUGHT-IRON PLATES, PER FOOT SUPERFICIAL.

THICKNESS.	⅛″	¼″	⅜″	½″	⅝″	¾″	⅞″	1″
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
	5	10	15⅛	20⅙	25¼	30¼	35⅓	40⅓

The lengths of wrought-iron chimney bars are entered in the dimension book with their width and thickness. Iron hooping is taken by length, the width and gauge being described. Sheet iron, used as linings to the panels of doors or shutters, is measured by the superficial foot, and thickness described. Screw bolts, with nuts, plates, etc., are numbered, with a description of the diameter, length, etc.

Wrought-iron sashes, fanlights, skylights, casements, etc., are taken by the foot superficial; guard or saddle bars by weight. The lead used in running iron into stone is to be taken by weight.

Iron roofing is measured by the square of 100 feet, taken on the slope of the rafters; and corrugated iron roofs must have an allowance, in taking the dimensions, of one-fourth for the laps.

Wrought-iron doors and frames are taken by the foot superficial, except those for furnaces, which are usually taken by weight.

If iron is galvanised, the area of the surface must be measured for the value of the galvanising.

Iron set-pots and coppers are taken by weight, the labour of fixing being taken with the bricklayer's account.

When copper is used for the covering of roofs, flats, or gutters, measure it by the foot superficial, describing the number of ounces to the square foot.

To estimate the cost of bell-hanging in private houses, take the number of the bells, including with each bell the wire, cranks, tubing, springs, carriages, etc.; state at the same time whether they are hung in peals; pendulums, levers and other pulls are usually numbered separately. Large bells are taken by the pound weight, the hanging being valued separately. Electric bells are valued according to the number of pulls which are supplied, and the distance which the wires have to be conveyed.

We will now further elucidate the measurement of the smith's work by an example of entries in a dimension book:—

2)	10 6	21 0	C. i. holl. col., 6″ external and 5″ internal diamr.
2)	14 6	29 0	C. i. T girder, flanges 10″ × 2″ and 3″ × ½″, web 12″ × 1¼″.
	25 6	25 6	5″ O. G. gutters.
	28 6	28 6	6″ ½ round eaves, ditto.
	48 0	48 0	3″ R. W. P.

No. 2 heads. 2 shoes. 2 nozzles. 2 angles to O. G. gutter.

	10 6	10 6	C. i. balcony, 21″ high, with w. i. top rail and standards.
	25 0	25 0	Ditto coping to 9″ wall.

No. 2 c. i. coal plates with hooks.
„ 4 air-bricks.

	2 6 1 6	3 9	C. i. casement and frame.
6)	8 0	48 0	W. i. chimney bar, 2″ × ½″.
10)	6 6	65 0	1″ round w. i. guard bar.

5 lb. lead for running bars.

2)	5 6 1 3	13 9	¼" in. w. i. shelf.
	25 0	25 0	W. i. top-rail, 2½"×½".
40)	3 3	130 0	1" sqre. w. i. bars.

No. 40 pointed ends to bars.
,, 40 cutting holes for bars in rail.
10 lb. lead for running.
No. 1 w. i. frame and door to copper.

	6 0 2 6	15 0	½" w. i. door and frame.
4)	2 0 1 3	10 0	⅛" sheet-iron linings to panels.

No. 1, 4 ft. 6 in. kitchener.
,, 2, 3 ft. register stoves, polished steel front.
,, 4, 2 ft. 6 in. ditto, Berlin black.
,, 1, 20" copper, 20 oz. to the foot.
Hanging 10 bells with copper wire, cranks, concealed tubing, springs, brass T-plate back carriage, pendulum, etc., complete.
No. 4 ornamental lever pulls.
,, 1 brass knob, pull, and plate. 1 brass slide pull.

ABSTRACT.

CAST IRON.		WROUGHT IRON.		BELLHANGER
Hol. columns, 6" diamr. ½" thk. ft. 21 0 27 567 lb. T girders. 29 0 123¼ 3574¼ 567 4141 36 cwt. 109 lb. SUPL. Casemt. and frame. ft. 3 9	Run. 5" O.G. gutter ft. 3)25 6 8½ yds. 6' ½ round eaves gutter. ft. 3)28 6 9½ yds. 3" R. W. P. ft. 3)48 0 16 yds. Balcony 21" high, w. i. top rl. and standds. ft. 10 6 Coping on 9" wall. ft. 25 0 NUMBERS. Heads and shoes to 3" R. W. P. 2 Nozzles. 2 Angles to O.G. gutters. 2 Coal plate and hook. 2 Air-bricks. 4	Chimney bar, 2" × ½". ft. 48 0 3 144 lb. 1" round guard bar. ft. 65 0 3⅓ 217 lb. ¼" shelf. ft. 13 9 10 137½ lb. Rail, 2½" × ½". ft. 25 0 3¾ 93¾ 1" bars. ft 130 0 3⅓ 433 lb. Lead for running. 5 10 15	SUPERF. ½" door and frame. ft. 15 0 ⅛" sheet iron linings to panels. ft. 10 0 NUMBERS. Points to 1" bars. 40 Holes in ½" rail. 40 Frame and door to copper. 1 4 ft. 6 in. kitchener. 1 Copper, wt. 14 lb. 1 3 ft. regr. stove, steel front. 2 2 ft. 6 in. ditto, Berlin black. 4	Hang. bells complete, cranks, tubing, spring, back carriage, pendulum, etc. 10 Orml. lever pulls. 4 Brass knob, pull, and plate. 1 Brass slide pull. 1

TECHNICAL DRAWING.—LXXI.

DRAWING FOR BRICKLAYERS.

EXTERNAL OR CAMBER BRICK ARCHES, AS APPLIED TO DOORS AND WINDOWS.

OUTSIDE arches are of two kinds, straight and semi-circular, or segments of a circle. Straight arches are perfectly horizontal above, and have the same appearance below, and unless the drawing be very large they are so represented. They should not, however, be quite straight, but should always have a rise of about half an inch in three or four feet, so that their intrados is an arc of a circle, like that of a segment arch; but the joints always radiate to some point much nearer than the centre of the said arc.

The bricks used in arches always show their thickness or edge in the face of the wall, which thickness being from two and a quarter to two and three quarters at the utmost, this dimension is used at the top of the straight arch, or at the extrados of the curved one, and thence it diminishes, owing to the splay of the arch-bricks, to the soffit of the straight arch, or to the intrados of the curved one.

This splay is termed the *sommering* of an arch. The bricks used in external arches are always rubbed with great care to the proper splay or wedge-like form necessary, and according to the gauges or regularly measured dimensions. For this reason they are styled *gauged arches*, to distinguish them from inside or *rough arches*, in which common bricks are used without being rubbed or shaped in any way.

A drawing of a straight-arched window is given in page 263, Vol. I., of THE TECHNICAL EDUCATOR, and to this the student is referred.

It will be evident that in a straight arch no two voussoirs, or arch-bricks, as they may be termed, on the same side of the centre, or key of the arch, are alike; but those of the contrary sides will correspond with each other, pair by pair.

In semi-circular or segment arches, on the contrary, all the arch-bricks between every two of the adjacent radiating points are exactly alike.

The number of bricks in a semi-circular arch is determined by finding how many thicknesses of a common brick are required at the extrados or outside of the arch, and from the points of division drawing lines to the centre of the arch, which will determine the splay, and give the rule for rubbing the bricks to their proper form.

Semi-circular, or segmental arches, are commonly used over the recesses in which doors or windows are situated, and the aperture within is also usually arched over by a concentric arch of a smaller span. In such cases the upper or greater arch is usually made a brick and a half in thickness, but the lower, or smaller arch, within the recess is made only one brick thick, being equal to the face of the thin wall on each side of the aperture within the recess.

The exterior and interior elevations of a segmental window have been given in page 264, Vol. I., of THE TECHNICAL EDUCATOR.

The example given in Fig. 585 represents a semi-circular arch of four feet width and one brick in thickness at top. This is a portion of the elevation of one of the arches over several of the doors of the officers' quarters in the Ordnance Barracks at Chatham. These doorways are 7 feet 6 inches high from the upper step to the spring of the arch. They are situated within a recess, the outline of which only is given in the present figure, the upper or second arch being omitted for the sake of clearness.

Fig. 586 is the half elevation of one of the arches of the recesses about the same doorways, which are one brick and a half in thickness; the arch of the doorway itself, illustrated in the previous figure, appears only in outline in the present example.

It is to be observed that the length of ornamental arches of this description thrown over a recess, as measured from the face of the wall inwards in a barrack or dwelling-house, never exceeds half a brick, or about 4½ inches, unless the thickness of the wall should be greater, which is not usual.

In like manner the length of an ornamental arch above a door or window, whether situated within a recess or not, never measures more than half a brick, unless the reveal be thrown further inwards, which is not usual in buildings of the above description.

Hence, such ornamental arches are mere shells, which support a portion of the wall towards the outside only. Accordingly if, as in the recessed doors alluded to in these barracks, there be a double semi-circular arch—namely, one over the recess and one over the door—these two between them support only eight or nine inches, or a thickness in the wall equal to about one brick, and therefore, of course, the rest of the thickness of the wall (which in the present instance is a two-brick thick wall) must be provided for in some other way. This is done by means of a rough brick arch on the inside, concentric with the two others, but of rather greater span than the smaller of the two, in order to allow for a "reveal" of the dimensions judged necessary.

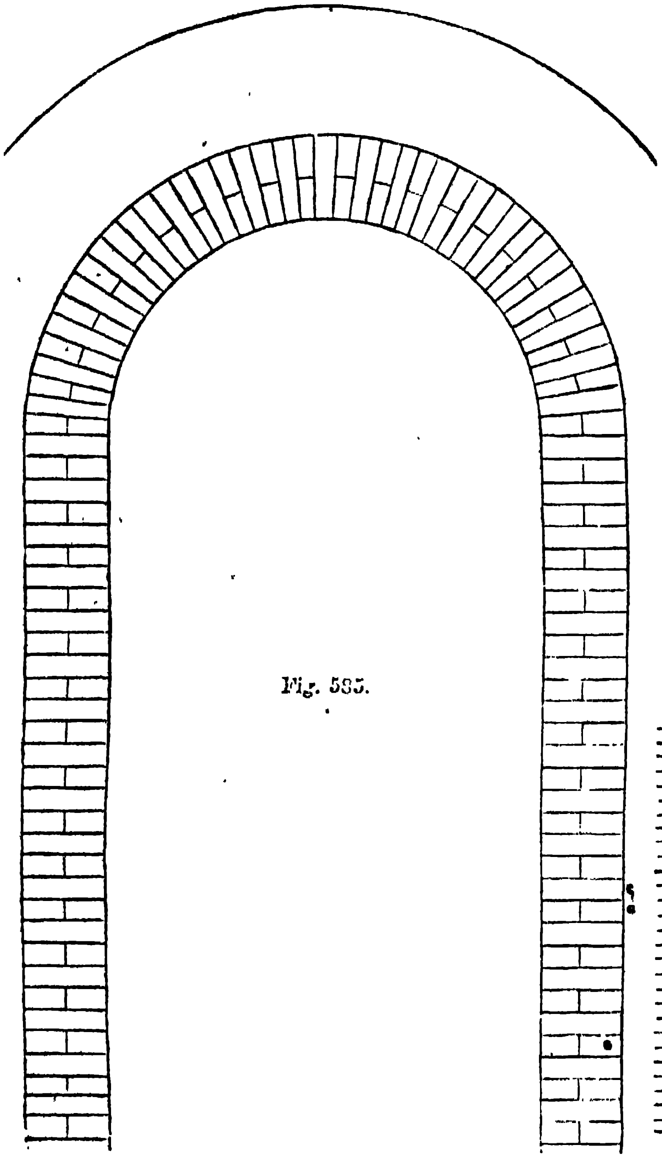


Fig. 585.

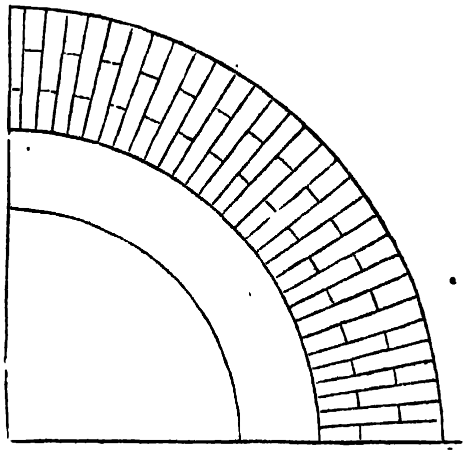
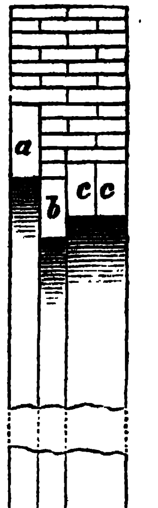


Fig. 586.



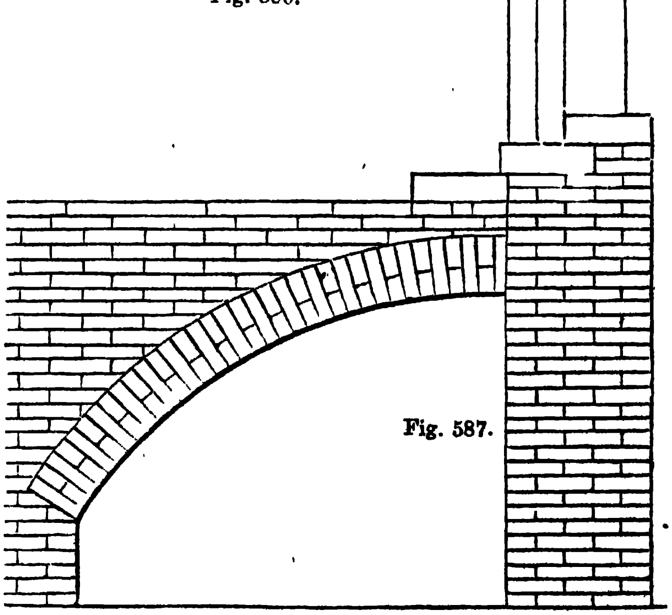


Fig. 587.

Fig. 587 is a section of one of these doorways, and represents this arrangement; *a* is the ornamental or external arch over the recess, which is a brick and a half high; *b* is the ornamental arch within the recess over the door, which is one brick thick. Each of these two arches is half a brick in length, measuring from the face of the wall inwards; *c* is the rough arch afterwards covered with plastering, which is one brick in height and one brick in length.

On examining this figure it will be seen that the two ornamental arches are by no means well connected. In fact, although each may support its own part of the superincumbent brickwork, there is no common bond between them. If, however, they be respectively executed with proper care, and in a workmanlike manner, and if the bricks and mortar or grout used be good, there is no risk of failure.

The execution of all the ornamental or thin arches in the face of a building, such as have been described, should be most carefully attended to whilst in progress. Bricklayers will always take sufficient pains to rub the outside of each arch-brick properly, so that their work may have a handsome appearance to the eye, but often slur over all the other parts of the work which are hidden from view. Hence, in order to save trouble, they are very apt to cut away the inside of the bricks of those arches to such a degree as may even deprive them of their proper wedge-like form everywhere except at the external surface. This neglect produces cracks, and causes the arch to bulge forward. It may even cause one of the bricks of a straight arch to drop down lower than the soffit or bottom of the arch, which defects may frequently be observed over the windows of common brick buildings.

In respect to ornamental arches of one brick in thickness and only half a brick in length, of which a specimen is given in Fig. 585, it is advisable that none but whole bricks should be used in constructing them, because the use of the two bats in every alternate voussoir, as appears in the figure alluded to, would in practice weaken the arch in some degree. But in this case false joints may be represented in every alternate voussoir, should it be thought that the mixture of small joints would better accord with the general effect of the other parts of the brickwork.

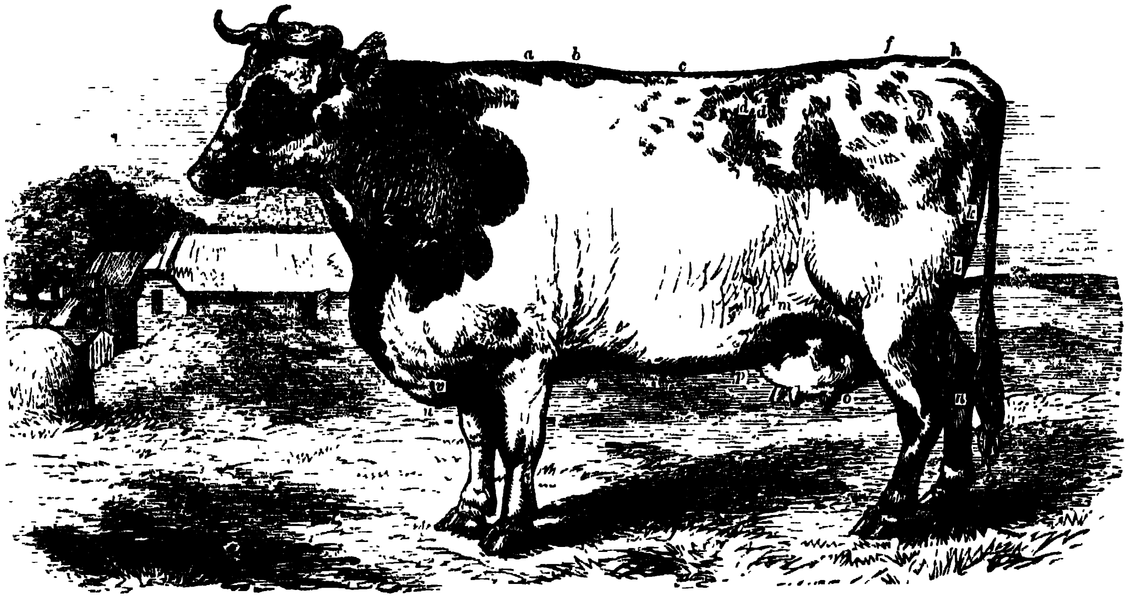
FARMING AND FARMING ECONOMY.—XIV.

By Professor **Wrightson**, Royal Agricultural College, Cirencester.

SHORT-HORNS.

INTRODUCTORY REMARKS—SKETCH OF HISTORY—PRINCIPLES INVOLVED IN BREEDING CATTLE—IN-AND-IN BREEDING—"POINTS" OF SHORT-HORNS.

We propose to devote a chapter to the study of short-horns. We do so because no race of cattle has had such a rapid rise, has been so "artificially" produced, has obtained such a wide-spread popularity, or possesses such a combination of those aptitudes for which cattle are prized. The skill of the breeder has been lavished upon it, and the material upon which such skill has been exerted has possessed the necessary plasticity to ensure success. Reference has already been made to the extraordinary prices recently paid for short-horns, and the records of public sales during the last year clearly indicate the high estimation in which these animals are held. We, however, fear that the exaggerated value now set upon pedigree is introducing an element of decay. Rigorous selection and a keen regard for personal merit especially require enforcing, and without undervaluing pedigree we think that it is too much relied upon at the present day as the test of value. Without further comment we propose to commence the consideration of this remarkable race of cattle with a short history of its rise and gradual diffusion over this country. We shall next devote a little time to the principles that guided its early promoters, and lastly, give the points looked for in first-rate examples of the breed.



SHORT-HORNED COW.

a, Shoulder-top; *b*, crops; *c*, chine; *d*, hook, hip or pin bone; *d'*, space; *e*, loins; *f*, ridge; *g*, beef-bed; *h*, set-on of tail; *i*, rump-bone; *k*, twist; *l*, buttock; *m*, flank; *n*, hock; *o*, udder; *p*, fore-udder; *u*, dew-lap; *v*, breast; *w*, shoulder-points; *x*, neck-vein.

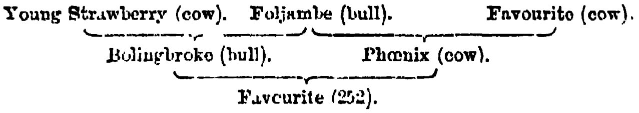
The short-horn must be a familiar object to almost every one. Who has not admired the tranquil scene of cattle grazing or resting in rich meadows, or standing knee-deep in water, shaded from the sun by magnificent trees? Such pleasing additions to the landscape cannot fail to attract and charm the eye, and we accept them as the happiest manner of introducing our bovine friends. But are these short-horns? If, we answer, he herd consists of red and white horned cattle, in which the wo colours named are pleasingly diversified, one animal being ed, another white, a third red and white, while a fourth is robably a rich roan, we may generally assume that we are ither looking at short-horns, or animals strongly impressed with short-horn character. Such cattle are now generally distributed throughout the United Kingdom; but within the last seventy years they were almost exclusively confined to the counties of Durham, Yorkshire, and Northumberland. To give more than the merest outline of the history of short-horn cattle would be impossible in a short article like the present; we must therefore deal with the subject generally, and at the same time with the utmost conciseness.

Robert Bakewell, of Dishley, Loughborough, Leicestershire (born 1726, died 1795), must be credited with having first turned the attention of agriculturists in the direction of improving their live stock. It was in his hands that the old English black horse, the Leicester sheep, and the famous long-horn or Leicester cattle, were brought to perfection; and there is no doubt that his example and precepts were followed by the brothers Colling, of Barmpton and Ketton, in their successful endeavours to improve Durham cattle. Long previous, however, to the time of the Collings, the Durham breed had been preserved with care. Thus pedigrees had been kept in some cases from the time of the cattle murrain, in 1745, and the Dukes of Northumberland, the St. Quintins, the Pennymans, Milbanks, and other county families, had for long taken a pride in their cattle. It also appears that a Mr. Dobison, of The Isle, Sedgefield, used a Dutch bull with success, and other breeders followed his example with rather prejudicial effects. The improvement of the county cattle, thus commenced, received a wonderful impetus from the labours of Charles and Robert Colling, who, by collecting together the best females, and allying them to sires of unrivalled merit, succeeded in laying the foundation of a breed which has found admirers in every district of this country, and seems destined to extend over a large portion of the civilised world. In 1810 Mr. Charles Collings' short-horns were sold at Ketton by Mr. Kingston, auctioneer, at an average of £151 8s. over forty-seven head, and in 1818 Mr. Robert Collings' cattle were dispersed at Barmpton, realising an average of £128 14s. 9d., over sixty-one head, old and young. In the first-named sale the bull "Comet" was sold for a thousand guineas, and in both many animals realised two, three, and four hundred guineas. The purchasers of this celebrated stock in turn became noted as the possessors of pure blood, and further extended the breed. The Chilton cattle, under the fostering hand of Mr. Mason, had long been famous, and the sale of this herd in 1829, at which Lord Spencer was a principal buyer, may be looked upon as the next leading event in short-horn history. Mr. Whitaker, of Burley, held his sale soon after, and in the language of "The Druid," Sir Charles Knightley, of Fawsley, gradually became quite a Whitaker of the Midlands. Mr. Richard Booth, of Warlaby, Yorkshire, and Mr. Bates (afterwards of Kirklevington), on the banks of the Tyne, were contemporaneous with the Collings. Both purchased bulls at Barmpton and Ketton, and both became so famous as breeders of short-horns that we shall have to again notice their proceedings. Such were the most eminent early improvers of short-horn cattle. With good material to work upon, they brought out animals which probably have never been excelled, and from their time down to the present the successes of breeders have rather been in the direction of maintaining and diffusing than in improving their favourite breed. No greater monument of the care taken in maintaining the purity of the race can be shown than the Herd Book, now numbering nineteen volumes, and containing the pedigrees of some 30,000 bulls, as well as a corresponding number of cows. Such a work also clearly shows the impossibility of giving in a single chapter even a faint idea of the many well-known strains of blood, the rival merits of which are keenly discussed by "short-horn men." Leaving, then, such highly technical details, let us turn to the consideration of those principles which were steadily adhered to by the early breeders of short-horns, and which led to such unprecedented success.

Previous to the time of Bakewell and the Collings it was usually thought impossible to fatten an ox under five years old, and Mr. J. Baily, who wrote the history of Durham, says, "I remember going to see a curiosity in 1786, a steer, three and a-half years old, of Mr. Robinson's, of Hutton, that was supposed to weigh eighty stones (fourteen pounds), and sold for £20." One principal improvement which has been effected is that of an earlier maturity, short-horn cattle now readily fattening at two to two and a-half years old; secondly, an increased aptitude to fatten, or an increase in the relation of beef produced to food consumed; thirdly, undiminished milking properties; fourthly, the reduction of offal or useless portions of the carcase, including bone; fifthly, beauty of form and colour; sixthly, "quality;" seventhly, docility. All these excellences have been developed in a marked degree in the improved short-horn, without any deterioration of constitution or hardihood, by observing certain rules, simple in themselves, but requiring a discerning eye, a practised touch, an almost passionate attachment to the pursuit of cattle-breeding, and, lastly, a bold outlay of money. With these requisites the improvement of cattle becomes a certainty; without them, an impossibility.

The rules or principles which the breeder keeps before him are apparently simple, but involve in their successful application great judgment and long experience. First, it is an axiom that "like begets like," which fact brings us face to face with the whole question of judicious selection. Good animals beget good animals, but the power of transmitting valuable characters varies in individuals. The direct influence of the parent upon the offspring is backed up by the more remote effect of past generations. This singular fact, so well known to every one, and yet so mysterious, is termed *atavism*, from *atavus*, an ancestor, and leads us at once to consider the value of pedigree or lineage. Offspring may therefore resemble a remote ancestor, a fact expressed by the term "reversion," and exemplified by the fact that well-bred cattle will occasionally throw inferior calves, representing unimproved and remote progenitors. These must be rigorously "weeded." The longer a tribe of cattle has been purely bred, the less likelihood is there of reversion to a bad type, and hence the importance of purity of blood, or pedigree. Thus we see that individual merit and an unstained lineage must both be regarded as essential. It will now be perceived that the breeder's art is complicated by various considerations, such as the personal merits of parents, descent, the judicious pairing of animals with a view to correct defects or develop good qualities, and, lastly, the feeding and treatment of the animals.

It is also worthy of attention that however unnatural a system of breeding from near affinities may be, it has succeeded admirably in the case of short-horn cattle. We often hear in-and-in breeding, or the breeding from close relationships, at once condemned as leading to disease, deformity, and imbecility. All races of animals cannot, however, be thus generally spoken of. With some, as in the case of horses and the pig, in-breeding is followed with pernicious results, yet cattle and sheep may be bred in this way for many generations, with advantage rather than otherwise. The bold policy of in-breeding pursued by early short-horn breeders is indeed singular, and, we cannot help thinking, conclusive in favour of the system as applied to cattle. Let us now briefly trace the origin of the Barmpton and Ketton short-horns, from which so many herds of the present day are descended. The Messrs. Colling possessed good cattle of the neighbourhood, but Mr. Robert Colling confessed that they never had better cattle than other people, until Mr. Charles Colling purchased the cow Favourite and her daughter Young Strawberry from Mr. Maynard, of Eryholme. Other good cows were also gathered together at Barmpton, and such formed the nucleus of the future herd. We now turn to the sires. The first bull which left his mark was the now celebrated "Hubback" (319), a bull picked up almost accidentally by Mr. Charles Colling, but which was subsequently shown to be possessed of a pure short-horn pedigree for several generations. This bull possessed, in a most wonderful degree, the power of transmitting his good qualities to his offspring, and his name lies at the foundation of all the pedigrees in at least one very important section of our short-horn herds. "Foljambe" (263) succeeded "Hubback," and "Favourite" (252) succeeded "Foljambe." Favourite (252) was himself the result of close interbreeding, as is shown by the following tabular view of his pedigree, commencing with the cow Favourite and her daughter Young Strawberry.



And yet Favourite was often used, without ill results, upon his own offspring for two generations. A cow by Favourite was put to Favourite, and the result was "Princess." Princess brought Nell Gwynne by Phenomenon (491), but on consulting the Herd Book we find that Phenomenon is by Favourite. Nell Gwynne put to Layton (366) brought another Nell Gwynne, and on investigating Layton's pedigree we find that he was by Minor (441), himself the result of two consecutive Favourite crosses, and out of a dam similarly imbued with Favourite blood. Again, taking the case of Janette by Wellington, a name which occurs far back in the pedigree of the "J" family, we find the following. Wellington was a grandson of Phenomenon, and by three previous crosses he was at once great, great-great, and great-great-great-grandson of Favourite. Still further, Janette's dam was by Phenomenon a son of Favourite, and, lastly, Janette's grandmother, great-grandmother, and great-great-grandmother were each by Favourite. Such was frequently the breeding of those earlier animals, whose progeny now rank highest in public estimation, and instances might be given to show that a similar system of close breeding has been pursued without apparent ill effects down to the present day.

At an early date in the history of short-horns two rival breeders, Mr. Bates, of Kirklevington, and Mr. Booth, of Warlaby, both of Yorkshire, came prominently before the public. It is scarcely too much to say that our most highly esteemed short-horns trace back to animals bred by either one or the other of these breeders. Booth and Bates' cattle are familiarly spoken of by short-horn breeders as representing two rival strains of blood, each party claiming special merits for his favourite. We do not propose to discuss this subject, as it would lead us into undue prolixity, but it is necessary to mention it, as the two strains are for the most part kept apart, and as a consequence certain distinctive characters have asserted themselves as peculiarly belonging to each family. Among the best examples of Bates' cattle at the present time are the Wetherby Duchesses, the property of Colonel Gunter; the Duke of Devonshire's herd at Holker, Lancashire; and Lord Dunmore's and Mr. Bowly's Kirklevingtons. Among Booth cattle we may mention the Warlaby herd, now in the possession of Mr. John Booth; the Aylesby herd, so long and carefully bred by Mr. Wm. Torr; and the Towneley herd, associated with the name of Colonel Towneley. We must conclude this brief account of short-horn cattle with the points of excellence usually looked for, many of which are common to other breeds of cattle.

The colour may be red, white, red and white, or roan, but black is not allowed on any part of the body. The hair is plentiful, long, lying in various directions, and of mossy, rich appearance. The animal is docile, the female carrying a sweet-looking head, with a quiet eye. Horns of moderate length in the cow; short, thick, and spreading in the bull. The muzzle is cream-coloured, and the horns are waxy, with streaks of red at the base. The bull has a noble carriage, and fine head, with hair curling over his forehead and between his horns. It is the head which gives what is termed "character" among breeders. The rump-bone, when the animal is lean, should be about two inches off, and the upper portion of it level with, the under side of the tail. When an animal is narrow at this point there is often a want of lean flesh and substance between the rump and hips. The quarter, or length from rump-bone to hip, should be long and full of lean flesh; the hips should be wide across, especially in the female, and the hip-bones rounded and well covered; the loin must be flat and wide; the space between hips and ribs moderate; the ribs well arched and deep, giving a round "barrel;" the back straight; the breadth of the loin maintained by the spring of the ribs, and shoulders wide across; the belly line parallel with the back, giving a uniform cylindrical body; the flank well let down; thighs heavy-fleshed and deep; buttocks full on both sides; shoulders snugly laid back into the crops; the bosom deep, wide and prominent; the neck thick at the base, but tapering to the head; the head broad between the eyes, and tapering to the muzzle. Whether viewed from front, back, sideways, or from above, the animal should approximate as nearly as possible in general outline to a parallelogram form. This is difficult to realise, but a glance at truly well-made cattle will convince the observer that a certain squareness of form is the best type of bovine symmetry. In addition to a correct form, short-horns must also possess the essential trait of "quality" or "touch." In other words, the skin must be soft, pliant, neither too thin (papery) or too thick (heavy), and moving with a certain characteristic ease upon the cellular matter beneath. This peculiar handling of cattle accompanies aptitude to fatten, and it is spoken of as "quality." Quality is also indicated by an abundant coat of fine silky, well laid hair. On comparing Bates and Booth cattle, we find the following points of difference. The former are unrivalled in "touch" or quality; the bulls have grand "Bates' character" heads, noble necks, and upright shoulders, rather hollow or deficient behind. Mr. Carr, the historian of Booth cattle, says: "The late Mr. Booth succeeded in imparting a length of quarter such as no other herd can boast, a marvellous fulness and depth of thigh, and of the twist or junction of the inside of the thighs, and a perfectly parallel and almost perpendicular position of the hind legs. It was, however, to the ample and symmetrical development of the fore-quarters that Mr. Booth's special attention was directed. He increased the obliquity or backward inclination of the shoulder-blade, thereby preserving the level line of the back, and promoting the free and graceful carriage of the animal. It was also his aim to improve the form and enlarge the capacity of the chest, which he did by augmenting the prominence or circularity of the fore-rib, and the width of the sternum or floor of the chest. It is to the success of Mr. Booth's efforts in this direction that we are indebted for those valuable and almost peculiar characteristics of the Warlaby cattle—the perpendicular fore-flank, which drops even with the arm; the roundness of the barrel-shaped crops, and the width or massiveness of the projecting bosom. The necks of the Booth short-horns are remarkable for their bulky and yet symmetrical development, gradually swelling as they approach and blend with the shoulders and breast, and completely hiding the shoulder-points even in the unforced animal."

We are compelled to leave the short-horn here, and to turn our attention to other important breeds. Such a sketch must be of necessity incomplete; but if we have given a good general idea of the history of the breed, the principles kept in view by those agriculturists who interested themselves in its improvement, and some faint idea as to what a good short-horn is, our task has not been in vain. The following works have been consulted in writing the above article:—"The History of the Killerby, Studley, and Warlaby Short-horns," by W. Carr; "History of Improved Short-horn Cattle," by T. Bell; "The Rise and Progress of Short-horns," by H. H. Dixon; Darwin's "Animals and Plants under Domestication," the *Agricultural Gazette*; Mr. Wright's Essay on Short-horn Cattle, and Mr. Thornton's "Short-horn Circular." In these any of our readers who may be desirous of obtaining further information will find many details, and much that is interesting and important that we have been precluded from entering into here. We need scarcely say that their perusal will amply repay the time spent over it, and furnish the cattle-breeder with many useful hints that might otherwise have been lost to him.

CIVIL ENGINEERING.—XIX.

BY F. G. BARTHOLOMEW, C.E., M.S.E.

LIGHTHOUSES (*continued*).

THE very limited period during which it was possible to work upon the Bell Rock—a period seldom exceeding three hours at a time—made it necessary to embrace every opportunity of favourable weather, as well by day as by torch-light by night, and also upon Sundays. The rise of the tide is so sudden that immediately the exterior parts of the rock were covered the workmen had to collect their tools, and betake themselves to the attending boats.

The first thing necessary to do at the rock was to erect a beacon to serve as a residence for the men during the working months. This beacon consisted of twelve large beams of fir timber, occupying a base of 30 feet diameter, and rising to a height of 50 feet above the rock. The spars were strongly framed with oak knees, and connected to the rock by iron bats set into holes, cut 18 inches deep in the rock, and wedged in. The upper part of the beacon was fitted up for occupation, the lower floor being employed as a smith's forge, and for preparing the mortar. Immediately over this was the cooking-house; above this were the cabins of the engineer and foremen, and over all the barracks for the artificers.

The occupied portion of this wooden structure was above the reach of the sea in moderate weather; but the lower floor was often lifted by the waves, and the contents washed away. The position of this beacon was near the site of the lighthouse, and after the erection of the latter had fairly progressed, the two structures were connected by a wooden bridge, which served as a stage from whence the materials employed in the building were raised from the rock. If the peculiar position and circumstances of the Bell Rock are taken into consideration, the great use of this beacon-house will be apparent. The rock was so constantly submerged, and the periods during which it was exposed were so short, and moreover the difficulty of landing upon the rock, owing to the violence of the surf, was so great, that had there not existed a temporary resort upon the rock itself, from which the workmen might without loss of time hasten to their duties, the commencement of the work would have been greatly impeded, and probably many lives lost. The beacon was vacated at the close of the summer, and again resorted to as soon as the storms of the ensuing winter and spring were over.

To facilitate the conveyance of the huge blocks of stone employed in the construction of the lighthouse, from the various landing-places at the rock to the site of the building, tracks of cast-iron rails were laid down and fixed to the rock. Two seasons were thus occupied in erecting the beacon, in cutting out and preparing the rock for the reception of the blocks, and in laying the first four courses of stone, which brought the height of the building 5 feet 6 inches above the foundation, and by the end of the succeeding season the building was raised to the height of 30 feet, which completed the solid portion of the lighthouse.

The state of the weather during the ensuing season, combined with the skill acquired by the men during the operations of previous years, enabled the building to be completed by the following October, at least so far as the masonry was concerned, and the light-room was finished in December of the same year.

This lighthouse is, like the Eddystone, circular. The two bottom courses of the masonry are sunk into the rock, and a very similar system of dovetailing to that of the Eddystone has been employed. The cement used was a mixture of pozzuolana, earth, lime, and sand, in equal parts by measure. The stones which compose the solid portion of the structure weigh from half a ton to two tons each.

The diameter of the bottom course is 42 feet, and the building diminishes in much the same proportion as the Eddystone, until the parapet-wall of the light-room is reached, where the diameter is reduced to 13 feet. The masonry portion is 100 feet high, above which the lantern rises 15 feet.

The first 30 feet from the ground is solid, and at this height the entrance is situated. The ascent from the rock to the entrance is by a kind of rope-ladder with wooden steps, which is hung out at ebb-tide, and taken into the building when the water covers the rock. The staircase rises 13 feet from the end of the passage, at which place the walls are 7 feet thick, and diminish to 12 inches in thickness at the parapet-wall of the light-room. The building contains six apartments, including the light-room. The floors are all of stone. The casements of the windows are all double, and are furnished with outer storm-shutters. The parapet-wall is 6 feet high, and outside it is a balcony surrounded by a cast-iron rail, resting upon a footing of brass, and surmounted by a coping of the same metal. The smoke-tube of cast iron which conveys away the smoke from the kitchen passes through the several apartments above it, and heats them.

The light-room and apparatus was constructed in Edinburgh. Its shape is octagon, and it measures 12 feet across, and 15 feet in height. The sashes are of cast iron, and the panes measure 2 feet 6 inches by 2 feet 3 inches. The glass is ¼ inch thick. The cost of the building and its establishment was about £60,000.

It is easy to perceive that apart from the difficulty of rearing a tall structure having a limited area of base, which is submerged every tide, capable of withstanding the shocks of heavy seas, one of the chief obstacles to be contended against in erecting a lighthouse upon an isolated and exposed rock lies in the difficulty experienced in landing men and materials, and in the limited period of time during which operations can be carried on in the early stages of the work. Some idea of what this difficulty is may be gathered from the narrative of the building of the lighthouse upon the Wolf Rock, and of the admirable precautions which were adopted by the engineer, Mr. Douglass.

The Wolf Rock is situated 23 miles W.N.W. from the Lizard, 20¾ miles E. by S. ½ S. from St. Agnes Lighthouse, Scilly, and 7¾ miles S.W. ⅓ S. from the Longship's Lighthouse. It consists of a hard porphyry, and its highest part is 17 feet above low water, and 2 feet below high water of spring-tides. The surface is sufficiently rugged to render a landing upon it difficult at all times. The water is very deep on all sides except the S.E., the depth being upwards of 100 feet. There is also a strong tidal current setting upon the rock. Its position is exceedingly exposed, and it receives the full force of the Atlantic waves, which burst upon it with incredible fury. So long ago as 1823 the Admiralty appear to have wished to erect a lighthouse upon this rock, but the estimate of fifteen years to build it, and the cost—£150,000—seems to have deterred them from the enterprise, and an iron beacon was subsequently erected by Mr. Thurburn, occupying in its erection from 1836 to 1840. Five years would appear to be a long period to expend in this undertaking, but the actual time occupied in working upon the rock was only 302½ hours during the whole five years, this limited period being entirely due to the danger and difficulty attendant upon the exposed position of the rock. The beacon, which consisted of a mast of selected English oak 12 inches in diameter, secured by stays fastened to the rock, cost £11,298 4s. 1d., and it was carried away in November of the same year in which it was completed. It was replaced by one of wrought iron, 7⅝ inches in diameter, in August, 1842. During the heavy weather of the succeeding winter this iron mast was bent about 3 feet from the perpendicular, and in October, 1844, it was broken off at about 4 feet above the top of the cone. A second iron mast was subsequently fixed, the diameter being increased to 9 inches, but this also was carried away in the early part of 1848. Another iron mast of equal diameter, but supporting a smaller globe, was then fixed, and this withstood the violence of the sea until taken down, during the construction of the present lighthouse.

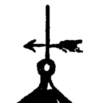
These particulars will serve to illustrate the force of the waves beating upon this rock. We shall not enter into a minute description of the magnificent structure which now serves to warn the mariner to avoid the dangers of the Wolf. A few of its leading characteristics will suffice.

The building is of stone, 116 feet 4¾ inches high; the diameter at the base is 41 feet 8 inches, but near the top, just below the springing of the curve under the lantern, it is reduced to 17 feet. The work is solid for 39 feet 4½ inches from the base, with the exception of a space formed for a reservoir for fresh water. The walls are 7 feet 9½ inches thick at the level of the entrance door, and gradually decrease to 2 feet 3 inches at the thinnest part near the top. The exterior face of the shaft is similar to that of the Eddystone and Bell Rock, being perhaps rather flatter in the curve. It contains 44,506 cubic feet of granite, weighing nearly 3,300 tons. Every external stone block is dovetailed to the adjoining block, both vertically and horizontally, the dovetails being 3 inches in height. In addition to this precaution, each block of the two lower courses is secured to the rock by two metal bolts 2 inches in diameter, and sunk 12 inches into the rock and wedged. In the next eighteen courses each exterior stone is secured to the course below by two 2-inch bolts of yellow metal, and each internal stone by two 2-inch bolts of galvanised puddled steel. These bolts are sunk 9 inches into the course below.

In order to economise time upon the rock, the blocks were all prepared and carefully fitted, and the bolt-holes all bored, in the yard on shore. The blocks to the level of high-water spring tides were set in fresh Roman cement, and from this point upwards in Portland cement. The cement was mixed with an equal portion of sharp granitic sand, obtained near Penzance, and salt water was employed in the mixture for all the solid portion of the work. Very little wood is employed in the structure, the ladders for ascending from room to room being of cast iron, as well as the partitions between the rooms and the staircase; whilst the doors, windows, and storm-shutters are of gun-metal. To facilitate landing upon the rock, a landing-platform has been constructed. This consists of small granite ashlar, set in cement, the stones of which it consists being 24 inches × 12 inches × 6 inches, the quantity of masonry being 14,564 cubic feet.

It not unfrequently happened during the early stages of the work that the surf increased so suddenly as to preclude the possibility of a boat landing to remove the workers, and upon such occasions they had to be hauled on board through the surf by a rope fastened round their waist; and during the cutting out of the foundation pit, it became necessary to sink heavy iron stanchions into the rock at intervals around the site of the foundation: each man working with a safety-rope lying near him, with one end attached to the nearest stanchion. An experienced man was always stationed on the highest point on the rock, whose duty it was to watch for the seas, and to give warning to the workmen to hold on to the lines, when, with head to the sea, it would wash over them, and frequently carry away the tools they had been using. In this manner eight working seasons were passed, during which 266 landings had been effected, and 1,809½ working hours spent on the rock. In spite of the height of this lighthouse—upwards of 100 feet above high-water mark—large quantities of water are not unfrequently thrown over the tower. The total cost of the building, including all incidental expenses, was £62,726.

That most useful material, iron, is not excluded from the construction even of lighthouses, having been successfully employed in more than one instance. One will suffice as an illustration, the cast-iron lighthouse at Bermuda, erected by



SCALE 24FT-1 INCH.

Fig. 44.—LIGHTHOUSE ERECTED ON THE MAPLIN SANDS.

Mr. Gordon. The site it occupies is not exposed to the wash of the sea; indeed, it might scarcely be deemed advisable to employ a material so liable to corrosion from the action of salt water as iron is, in a position where it would be subjected to its influence; it would certainly require the most constant and scrutinising attention.

The Bermuda lighthouse stands upon an elevation 250 feet above the level of the sea, and is itself 105 feet 9 inches high, and 24 feet in diameter at the base. It consists of concentric cast-iron plates, 135 in number, and moulded to the external contour of the shaft. The plates vary in thickness from 1 inch to ¾ of an inch, and are cast with flanges on the inside 4 inches broad, reckoning from the exterior surface of the plates, which are further strengthened by ½-inch feathers placed at intervals of 12 inches.

Holes ¾ inch in diameter are drilled 6 inches apart in all the flanges, both vertical and horizontal, to receive ¾-inch screw-bolts, by which the several plates are united. In the centre of the lighthouse is a hollow column of cast iron running from bottom to top, 18 inches in internal diameter, and 19½ inches in external diameter. Upon this rests the optical apparatus, and the weight by which its revolution is maintained descends through this hollow shaft. The column is cast in nine lengths, each length terminating externally in broad circular flanges, which serve the double purpose of connecting the sections together, and of supporting the floor-plates. This shaft is also employed in raising stores from one floor to another, for which purpose there is, at a height of 2 feet above each floor, an opening left, 26 inches high and 15 inches wide, furnished with a door. The lower portion of the tower is filled with concrete to the height of 20 feet, with a well in the centre 8 feet in diameter, lined with brickwork. There are seven floors, each 12 feet high, the lower two being cased with brickwork. The upper five are lined with sheet iron. Each floor is furnished with five windows, 18 inches square, fitted with plate glass. The staircases, with the exception of the treads, which are of oak, 1½ inch thick, are wholly of iron. The light is visible at a distance of upwards of eight leagues. The total cost was under £8,000.

There is a cast-iron lighthouse erected upon the Fastnet Rock, an isolated crag situated a few miles off the southernmost point of Ireland, and rising 60 feet above high-water mark. The dimensions of the tower are—height from base to gallery, 63 feet 9 inches; height of lamp above the gallery, 11 feet; height of lantern, 30 feet; outside diameter of base over the stone moulding, 23 feet; outside diameter of cast-iron shell at base, 19 feet; outside diameter, below the cornice, 13 feet 11¼ inches; thickness of plates at the base, 1⅜ inch; thickness at top, ⅝ inch. The mode of construction is nearly identical with that at Bermuda.

When a lighthouse is required to stand upon a soft, yielding base, as sand, screw-piles are employed with great advantage. There are several instances of such structures. One of the earliest is that at the Maplin Sands, erected in 1841. The building rests upon nine wrought-iron piles, 26 feet long and 5 inches in diameter, furnished with cast-iron screws, whose blades are 4 feet in diameter. The piles are screwed into the sand to a depth of 22 feet, leaving 4 feet standing above the soil. One pile occupies the centre of the building, and the remaining eight stand at the angles of an octagon formed round the central pile. The upper portion of the piles enter the hollows of cast-iron sockets forming the lower extremities of the supporting columns. The central column is perpendicular, the remaining eight incline inwards, and the whole nine support the platform, house, and lantern. The columns are strongly braced together by wrought-iron rods, the braces being horizontal below the water-line, supporting the columns at a point midway between the top of the piles and the bend of the columns; and diagonal from the angle of the bends themselves to the central column, rising and falling above and below the horizontal plane of the bends. The entire absence of opposition to the waves offered by the columns is a notable and excellent feature in this form of structure.

In Fig. 44 we give a sketch of the lighthouse erected on the Maplin Sands.

There are many other lighthouses erected upon piles, all of which have stood well. That at the *Gunfleet* stands on seven screw piles, screwed 40 feet deep into the sand. Another, at the *Point of Ayr*, stands on nine piles, screwed 12 feet into the sand. There is a small lighthouse standing upon piles at *Mucking Reach* in the Thames, a few miles below Gravesend.

A remarkable and successful instance of lighthouse engineering occurred some years since at Sunderland. Owing to the construction of a jetty, the lighthouse, which had stood upon the old pier, became useless in that position, and it became necessary either to pull it down and rebuild it upon a situation where it would be of use, or to remove it bodily. The distance of the new site from the old was no less than 475 feet, and was not in one direct line, and the difficulty and risk attendant upon adopting the latter course will readily be appreciated: adopted it was, however. The weight of the structure was 757,000 lb.; it consists of an octagonal tower 64 feet high, and 15 feet in diameter at the base; and not only had it to traverse the distance mentioned, but it had to be turned upon its axis, and the new site was 19 inches higher than the old.

The method employed was generally much the same as that employed in the removal of large masses of masonry, with certain modifications to suit the shape of the building. A series of openings were made in the base of the tower, and into these beams were introduced, united together by cross-beams, so as to form a substantial and very strong flooring or platform of oak. In order to steady the tower, a framework of shores or props, resting on the platform, abutted against the tower from the base to the summit, the stays being strengthened by crossbeams.

The platform rested on 144 cast-iron flanged wheels, and the masonry below the platform having been very gradually removed, iron rails were introduced below the wheels, and thus by degrees the whole structure was made to rest upon the wheels, which ran on eight parallel rails, laid upon the pier, along which the lighthouse was required to move. The whole mass was moved forwards along the rails by iron chains attached to the platform, and wound upon windlasses. The entire operation was accomplished in about 13½ hours, and so successfully that no interruption occurred in the lighting of the lantern, not even for a single night.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XV.

BY E. WYNDHAM TARN, M.A.

PLUMBER.

The work of the plumber consists in the laying of lead on the roofs, gutters, etc., of buildings; lining wood cisterns with lead; laying down lead or iron pipes for water-supply; fixing cocks, water-closet apparatus, soil-pipes, pumps, etc.

There are two kinds of lead used for roofs and linings to cisterns, cast lead and milled lead; the former is now seldom used, though it is often found on old buildings. Milled lead, which is now generally used, varies in thickness, which is reckoned according to the number of pounds' weight in each square foot, as 4 lb., 5 lb., 6 lb., etc. In measuring plumbers' work take the exact area of the lead, describing the weight per foot, and multiply the area by the given weight in the abstract, which will give the weight of lead used. In the bill all sheet lead is brought into cwts. and lbs., and the different parts of the work kept separate. In taking the dimensions of lead covering to roofs, sufficient allowance must be made for the laps and dressings over the rolls; and in gutters an allowance is to be made at the drips for turning up the lead.

In taking the lead linings to cisterns, measure the exact quantity of lead, take the run of the soldered angles, and also the nailing to the edges with copper nails. Number the solderings for letting in pipes, washers, etc., to the cisterns, also all plugs, washers and wastes, air-traps, screw or driving ferrules, stop-cocks, bib or ball cocks, stating whether zinc or copper balls are used, and giving the size or diameter of the bore of each cock.

All lead pipe is taken by the foot-run, the diameter of bore being stated, and whether common, middling, or strong pipe is used. The soldering to the joints, which are required in laying or connecting pipes, is generally included in the price of the pipe and laying; but solder joints for attaching cocks, etc., are numbered, describing the size of pipe. Syphon traps formed by bending pipes are numbered as extra upon the measured length. Trumpet-mouthed standing water-pipes in cisterns are numbered, giving the height and diameter at bottom; also number the lead service-boxes soldered into the bottom of the cistern for the supply of the water-closet. The apparatus for water-closets are numbered and described; the D or P traps thereto are numbered separately, and the soil-pipe by the foot-run, describing the diameter and weight per foot; bends to soil-pipe are measured separately from the straight part, and all soldered joints are numbered. The lead safe, laid underneath the closet apparatus, is measured by the foot superficial as in cisterns, and the soldered joints by the foot-run.

Pumps are numbered, describing the diameter, and whether suction or force pumps, single or double; the pump-rods for deep wells are in lengths of 10 feet with joints and brass couplings, and must be measured by the foot-run.

ZINC-WORKER.

Zinc is used in a similar manner and for similar purposes to those for which lead is applied, as in the covering of roofs and flats, valley and hips, flashings, linings of gutters and cisterns. The area is measured with proper allowance for laps and rolls, and if cut away at a slant the full width of the widest part must be measured, and no deduction made for the part cut away, as there would be in lead. The thickness or gauge is stated as so many ounces to the foot, but it is not brought into cwts. and lbs. in the bill, the price being stated at per foot superficial, according to the position in which it is laid, whether in flats, roofs, gutters, flashings, corrugated, etc. Zinc eaves gutters and rain-water pipes are taken and billed out at per foot-run, numbering the heads, shoes, bends, nozzles, stopped ends, angle-pieces, etc.

GAS-FITTER.

The pipes used for conveying gas to various parts of a building are of two kinds, iron and tin; the iron pipes being used for the principal part of the work, and in carrying the gas from floor to floor, and the tin pipes for branching therefrom to the burners and chandeliers. The iron pipe is in lengths of from 4 ft. to 12 ft., and must be measured with an allowance of so many lengths: if short pieces of 2 ft. to 4 ft. are used, they are measured separately at per foot, pieces under 2 ft. being numbered; the internal diameter of the tubing must be stated. Number all bends, elbows, tees, cross-pieces, connecting pieces, plain or diminishing sockets, flanges, union joints for tin pipe, stop-cocks, nose pieces, etc. Tin gas-pipe is to be measured by the foot length, describing the diameter. Gas brackets are numbered and described, giving the length of the tube, whether single, double, or treble jointed. Pendants, chandeliers, standards, etc., are numbered and described.

GLAZIER.

In measuring the glass stopped into sashes, sash doors, fanlights, skylights, etc., take the dimensions between the rebates, if the opening is rectangular, and the greatest width and length, if the shape is irregular; bring into superficial feet, describing the size of the squares, and the quality of the glass, whether best, seconds, or thirds crown; if sheet glass, state the number of ounces per foot superficial, as well as the quality; if plate glass, state whether best or seconds glazing quality, the size of each square and the thickness. If the glass has to be bent to a sweep, it is measured extra per foot superficial.

Glazing in lead quarries, with crown or cathedral glass, is taken by the foot superficial, including the lead-work and copper ties, an allowance all round being made for letting into the groove in the stone-work; and if the heads are arched they must be measured the full height by the width, as if square. Saddle bars are taken separately, by weight, with the smith's work.

Hacking out old or broken glass is taken by the foot superficial, in addition to the stopping in of the new glass. Also obscuring or frosting glass to imitate ground-glass is taken by the foot superficial.

Cleaning windows is numbered by the window, and if in small squares of glass, by the dozen squares. Grinding or polishing the edges of plate glass is taken by the inch-run, and circular cutting by the foot-run. Glass tiles or slates are numbered according to their respective sizes.

PAINTER AND DECORATOR.

The painter's work on deal or other woods must be measured separately from that on plaster, cement, iron, or other material; as in painting on deal the work has first to be knotted, and any defects stopped, and then primed, after which it receives the stated number of coats, generally described as so many oils. All large works, as doors, framing, walls, etc., are measured by the yard superficial, with an allowance for all edges, mouldings, sinkings, projections, etc., in taking the dimensions. Carved work may be taken by the foot superficial. Skylights of large size may be measured by the superficial yard, but entered separately in the bill.

Where the work has to be cut in on one or both edges, as in edges of stairs cut for carpets, skirtings, rails, newells, rain-water pipes and gutters, reveals, cornices, staff beads, shelf edges, strings of stairs, etc., it is taken by the foot-run.

The paintings to sash frames is taken by number, describing the size, and whether ordinary or Venetian. Sashes and casements have the number of squares taken by the dozen, if small, but large squares are taken singly.

Iron railings and balusters of stairs have the painting measured, as if it was solid work, the height by the length on both sides.

Small articles, as bell-boards, scrapers, shutter-bars, chimney-pieces, etc., have the painting to them taken by number and description.

Graining and varnishing is measured by the yard superficial, except for hand-rails, which are taken by the foot-run, the character of the imitation is described, and also the number of coats of varnish.

The description of painter's work must include the number of coats laid on, whether finished in common or extra colours, or with a flatting coat; also whether prepared for graining. In repainting to old work it must be described as rubbed or pumiced down previous to being painted.

Staining, sizing, and varnishing to deal, in order to bring out the natural grain of the wood, is measured by the superficial yard.

Writing or painting letters or figures is taken by the inch-run, describing the height and character of the letters, and whether plain or shaded.

Gilding is measured by the foot superficial, carved work being taken separately; and mouldings by the foot-run, describing the size.

Distempering is measured by the superficial yard, describing the tints used, and if more than one. Imitations of Scagliola are measured by the foot superficial.

PAPER-HANGER.

The hanging of paper to walls is measured by the foot superficial, and the area thus found is entered in the abstract and divided by 5, to bring it into linear yards of paper 20 inches in width, which quantity is divided by 12, to bring it into pieces, as nothing less than a piece of 12 yards length can be taken. Common papers, however, do not nett more than 11 yards to the piece in the general way, so that a full allowance must be made. If the paper is hung to new walls, describe the sizing of the walls, and hanging with a lining paper previously to hanging the decorative paper. If the walls have been previously papered, then take the pumicing, sizing, and stripping with the description of the papering.

Canvas lining over panelled framing, or where the surface is not even, is measured by the superficial yard. If the paper is hung in blocks, as marbled papers, or if in panels, it must be so described, and whether lined, sized, and varnished.

Borders to paper-hangings are taken by the dozen yards, unless of superior quality, when they may be taken by the single yard.

Gold or black mouldings fixed upon the papering with needle-points are measured by the yard-run, describing the width.

We shall now apply the foregoing rules to taking out the quantities in each of the above-named trades, and then proceed to form an abstract thereof, previously to bringing them into bill.

PLUMBER.

2)	24 0		7 lb. milled lead on roof.
	15 0	720 0	
	25 0		6 lb. ditto gutters.
	1 6	37 6	

2) 30 0 1 9	105 0	Ditto, ditto, hips.
34 0 1 3	42 6	5 lb. ditto step flashgs.
15 0 2 6	37 6	6 lb. ditto cisterns.
5 0 2 6	12 6	7 lb. ditto, ditto.
17 6	17 6	Soldered angle to cistern.
15 0	15 0	Close nailing with copper nls.
45 0	45 0	1 in. strong lead pipe.
12 0	12 0	¾ in. ditto.
35 0	35 0	1¼ in. ditto.
16 0	16 0	1½ in. ditto.
32 0	32 0	3 in. soil-pipe.

No. 2 solder jts. to 1¼-in. pipe.
„ 2 ditto, 1-in. pipe.
„ 2 ditto, ¾-in. pipe.
„ 2 ditto, 1½-in. pipe.
„ 2 1½-in. brass washer and waste.
„ 1 1¼-in. trumpet-shaped standing waste 2 ft. 3 in.
„ 1 lead service-box, soldered.
„ 1 1¾-in. ball-cock and copper ball.
„ 1 1-in. stop-cock.
„ 1 ¾-in. bib-cock.
„ 1 D-trap.
„ 1 W. C. apps.
„ 1 syphon-trap in 1½-in pipe.
„ 1 brass gratg., soldered.
„ 1 2½-in. br. force-pump.

ZINC-WORKER.

12 0 10 6	126 0	25 oz. zinc in flats.
24 0	24 0	4 in. eaves gutter.
2) 15 0	30 0	2½ in. R. W. P.

No. 2 octagon heads. 2 shoes. 2 nozzles.
„ 4 stopped ends to gutters.

GAS-FITTER.

55 0	55 0	1 in. w. iron welded tubing.

No. 5 short pieces 1 in. w. i. tubing.
„ 3 bends to ditto.
„ 2 tees to ditto.
„ 1 cross to ditto.
„ 1 connecting piece.
„ 1 1-in. stop-cock.

30 0	30 0	½ in. tin pipe.

No. 8 ½-in. union joints.
„ 4 plain brackets, 12 in. long.
„ 2 ditto, double jointed, 24 in. ditto.
„ 1 plain pendant, with hydraulic joint.
„ 5-light chandelier.

NOTABLE INVENTIONS AND INVENTORS.

XXIX.—SIR ISAMBARD BRUNEL (*continued*).

BY JOHN TIMBS.

WE mentioned at the conclusion of the first part of this memoir the machine invented by Brunel for making shoes for the army. After two years' trial the manufacture of shoes by this machine was given up from an economical motive. By this and another speculation Brunel got into difficulties, from which he was extricated by a Government grant of £5,000, in consideration of the savings by the use of his block machinery. He then improved the stocking-knitting frame and the steam-engine, the manufacture of metallic paper and crystallised tinfoil, stereotyping, and the treadmill. Among other things he invented machines for making wooden boxes; for nail-making; for ruling paper; a contrivance for cutting and shuffling cards without the aid of the fingers, produced in reply to a playful request from Lady Spencer; a hydraulic packing-press; and a process for building wide and flat arches without centerings. In steam navigation he experimented with a boat on the Thames, fitted with a double-action engine, and made his first voyage in it to Margate in 1814, when he narrowly escaped personal violence from the proprietors of the sailing-boats. Marine engines and paddle-wheels were next improved by Brunel. He constructed a machine for using carbonic acid gas as a motive power; and, assisted by his son, carried on a series of experiments for more than ten years in the endeavour to bring it to perfection. Most of the mechanical difficulties were overcome; but although an intense power was obtained, and with a very low temperature, the economical advantages, as compared with the cost of the vapour of water, did not appear to be such as to compensate for the increased cost of the machinery and the usual difficulties in its use.

In different parts of the United Kingdom are to be found works of engineering construction by Brunel, who thus largely contributed to the wonders which in his boyhood he so ardently desired to see. His greatest work, and that by which he is most popularly known, is the Thames Tunnel, a brick-arched double roadway under the river, between Wapping and Rotherhithe. In 1804, two Cornish miners, Varey and Trevethick, commenced an archway from Rotherhithe to Limehouse, and the excavation had reached 1,040 feet, when the ground broke in under the pressure of high tides, and the work was abandoned. With such failure before them, fifty-four engineers declared it impracticable to make a tunnel under the Thames of any useful size for commercial purposes. Brunel, however, rose superior to this declaration, and planned a tunnel in 1823, when a company was formed, and the Duke of Wellington and Dr. Wollaston were the earliest subscribers to the scheme. A brickwork cylinder, 50 feet in diameter, 42 feet high, and 3 feet thick, was commenced by Brunel, at 150 feet from the Rotherhithe side of the river. Upon this cylinder, computed to weigh 1,000 tons, was set a powerful steam-engine, by which the earth was raised and the water was drained from within it. The shaft was then sunk into the ground *en masse*, and completed to the depth of 65 feet; and at the depth of 63 feet the horizontal roadway was commenced, with an excavation larger than the interior of the old House of Commons. Brunel devised, in 1814, this plan of operation from the bore of the *Teredo navalis* into the keel of a ship, the perforation of the worm being secured at the sides, and lined with a calcareous secretion, so as to be impervious to water. With the auger-formed head of the worm in view, Brunel employed a cast-iron *shield*, containing thirty-six frames, or cells, in each of which was a navvy, who cut down the earth; and a bricklayer simultaneously built up from the back of the cell the brick arch, which was pressed forward by strong screws. Thus were completed 540 feet of the tunnel, when the river burst into the works; but the opening was soon filled up with bags of clay, the water pumped out of the tunnel, and the work resumed. At the length of 600 feet, the river broke in again; six men were drowned, and the rush of the water carried Mr. Brunel's son up the shaft. The tunnel was again emptied, but the works were suspended seven years for want of funds.

In April, 1834, several members of the Royal Society, with Mr. Brunel, one of the vice-presidents, visited the tunnel to its extreme end, and Mr. Brunel showed the whole progress of the work, the great difficulties that had already been overcome in carrying the tunnel above 600 feet under the Thames; and the data being explained upon which the engineer confidently anticipated being able to complete this great undertaking, if the necessary funds were supplied. Brunel, at considerable length, detailed the exertions which had been made to overcome the difficulties arising from the irruption of the river, and stated that in the course of the work the miners had for twenty-seven days pushed on the tunnel over a quicksand.

The members of the Royal Society, after leaving the tunnel, proceeded to view an experimental arch constructed on a new plan by Mr. Brunel. This structure was built of bricks and Roman cement, and consisted of two semi-arches, springing from the same pier, without any support. By this plan an arch of the greatest span might be constructed without centering, and demonstrating, as the projector observed, the practicability of building a tower of brickwork 50 feet high and 200 feet in diameter, and sinking the whole gradually in one mass. By this method it was intended to complete the circular and winding carriage approaches to the tunnel. It may be interesting to observe that of the two semi-arches one was shorter than the other, and it had been loaded with about eleven tons of iron for the previous nineteen months without any sensible change in its position.

Mr. Brunel was not, however, discomfited by catastrophes in his tunnel, though, as Tom Hood sings—

> "Sad is it, worthy of one's tears,
> Just when one seems the most successful,
> To find one's self o'er head and ears
> In difficulties most distressful;
> Other great speculations have been nursed
> Till want of proceeds send them on a shelf:
> But thy concern was at the worst
> When it began *to liquidate itself*."

Many plans were now proposed for completing the tunnel, and above £5,000 were raised by public subscription. By aid of a loan sanctioned by Parliament, mainly through the influence of the Duke of Wellington, the works were resumed, and a new shield constructed in March, 1836, between which date and November, 1841, the shaft at Wapping was reached. The new shield consisted of 5,000 pieces, and weighed 150 tons. On March 24, in the same year, Brunel was knighted by Queen Victoria; on August 12, he passed through the tunnel, from shore to shore; and on March 25, 1843, it was opened as a public thoroughfare. On July 26, 1843, it was visited by Her Majesty. The tunnel cost about £454,000, exclusive of the carriage descents. The dangers in the progress of the works were many; yet, with all these perils, only seven lives were lost in constructing the Thames Tunnel, whereas forty men were killed during the building of the present London Bridge. At full tide, the foot of the tunnel is seventy-five feet below the surface of the water. Brunel has left a minute record of his great work in Weale's "Quarterly Papers on Engineering." A fine medal was struck on the completion of the tunnel—*obv.*, the head of Brunel; *rev.*, interior and longitudinal section of the tunnel.

This was the engineer's last work. Commercially, it proved disastrous, which preyed upon the mind of Sir Isambard Brunel, though he lived six years longer, until he had attained his eighty-first year, in 1849, when he died at his house near St. James's Park. In the gallery of portraits of inventors at South Kensington is an engraved portrait of Brunel, from the painting by S. Drummond, A.R.A. As a triumph of engineering skill, the tunnel is complete. Brunel's inventions, and their essential usefulness, show what may be accomplished by genius, seconded by industry and indomitable perseverance.

SANITARY ENGINEERING.—XXII.

THE VENTILATION OF HOUSE DRAINS AND THE DISINFECTION OF SEWER GASES.

In a previous paper we have given some instructions as to the ventilation of pipes—a subject to which hitherto we are afraid public attention has scarcely been sufficiently directed; and we now have to devote a similar amount of attention to the ventilation of house drains. As we proceed further we shall have to consider the question of the ventilation of public sewers; but this important subject has already, from the force of circumstances, fully occupied the attention of competent authorities, and the materials with which we have to deal are ready to our hand. In the present case it is not so; it is only within the last few years, or few months, we may say, that attention has been sufficiently drawn to the matter in hand, although it is one of the most important features of sanitary engineering.

In olden times—*i.e.*, before the last thirty years or so—when the greater part of our house drainage was carried by the old-fashioned brick-built "barrel-drain," the porosity of the brickwork, and the occasional imperfection of the joints provided, as it were, a system of natural ventilation, and although the subject really never had due consideration, the drains to a great extent ventilated themselves. But now that thoroughly glazed impervious pipes are used, with all the recent improvements in their manufacture, this is not the case; and if the matter is not duly considered and provided for, the better the character of the actual workmanship of the drainage, the greater the danger to health if ventilation is neglected, as the drains then become so many ducts for sewer gas, which is drawn into the house, and may, and not unfrequently does, exercise a most prejudicial influence on the health of the inhabitants. In rural districts, with detached and independent systems of drainage, as alluded to in our last paper, the question is comparatively easily dealt with, as if the reservoir or cesspool is away from the house, and is properly ventilated, no further danger can arise, except from an occasional or accidental obstruction; but in town houses, more especially large establishments draining into a large general system, further precautions are required, and as to the method of their practical adoption we give the following details.

In Fig. 47 is shown Mansergh's Patent Ventilating Trap. The section S is the pipe from the sink, drain, or closet, as the case may be. G is an open grating for surface-water, the water-line being clearly shown, and P is the ventilating pipe by which the sewer gas is allowed to escape. Objection is sometimes taken to allowing an escape of sewer gas "under the windows," as the phrase goes, as houses in streets must, of course, obtain their light and air from front or back. The remedy in this case is to carry the ventilating pipe up to the top of the house—not by any means a costly matter, as a common cast-iron rain-water pipe will answer the purpose perfectly—and the sewer gases are then discharged into the atmosphere at the level of the chimneys, where they are dissipated in the air, and become perfectly harmless. In cases where from peculiarities in the construction or position of the house this is difficult, still a ventilator of some sort should always be provided; and this axiom may be safely adopted, that outside the house sewer gas is rarely or never dangerous, but that it is when freely admitted within that its deleterious effects are felt. And here we may remark that water possesses an extraordinary power of absorbing these peculiar gases, and that the waste-pipe of a closed cistern may become the means, if improperly constructed, of impregnating the drinking-water of a whole family with ingredients which may without exaggeration be called poisonous.

We next give an illustration showing the facilities for ventilating a system of drainage at any part of its course, with the benefit of using a cane for the removal of obstructions. The system is known as Lovegrove's Patent, and may be employed either with or without a separate ventilating shaft if left open at the top. Fig. 48 shows the construction with the ventilating pipe, and Fig. 49 without it.

These are, of course, not the only methods in use; there are many others, but we quote those given as lucidly illustrating and exemplifying the principles to be adopted, and we now proceed to the second head of our subject—the disinfection of sewer gases. This is a question only recently brought before the public in a practical form, and the agent hitherto found most efficient, and therefore most generally used, is charcoal. We quote Dr. Watson on the *rationale* of its use:—

"All decaying animal and vegetable matters give off during decomposition fœtid and deleterious gases, which in the end tell as fatally upon the human constitution as the bite of a viper, or the most insidious poison known to the chemist. These deadly gases become in their passage through charcoal inodorous, and comparatively harmless. The explanation of this result is beautiful and simple.

"Charcoal is an extremely porous substance, presenting throughout its mass an almost incredible amount of surface, and upon this depends its power of absorbing various gases in

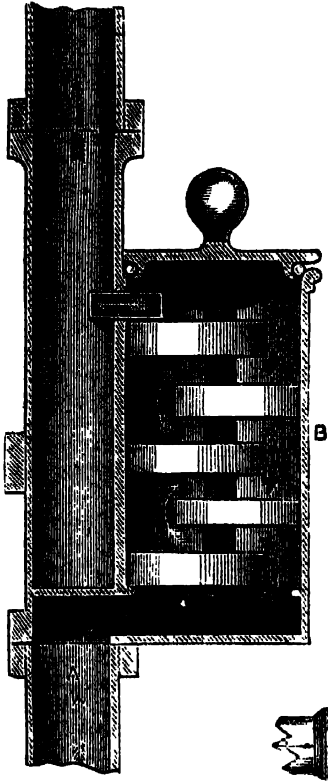


Fig. 50.

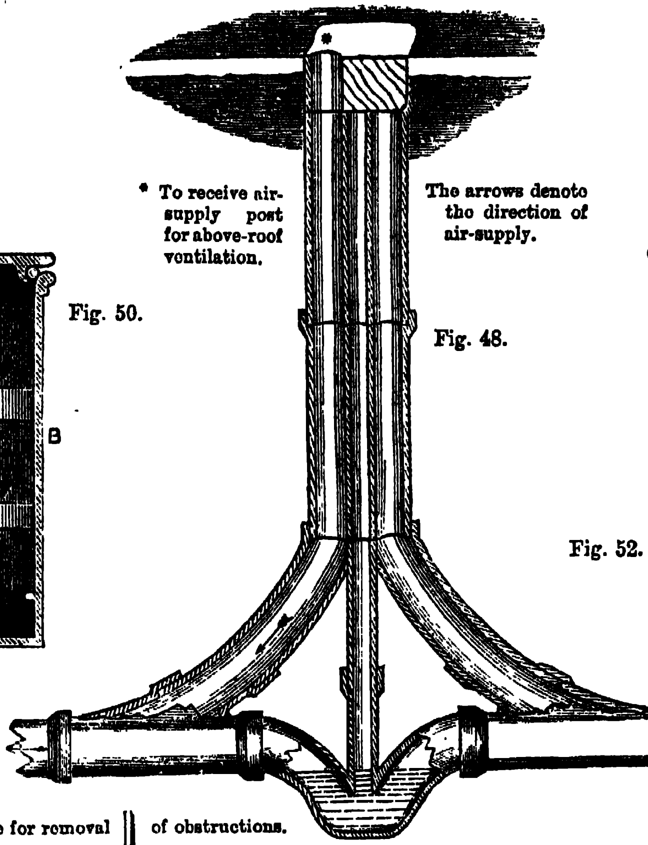

*
* To receive air-supply post for above-roof ventilation.
The arrows denote the direction of air-supply.

Fig. 48.

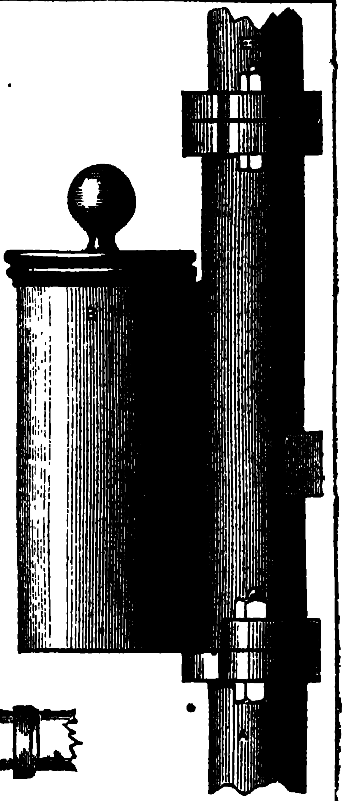


Fig. 52.

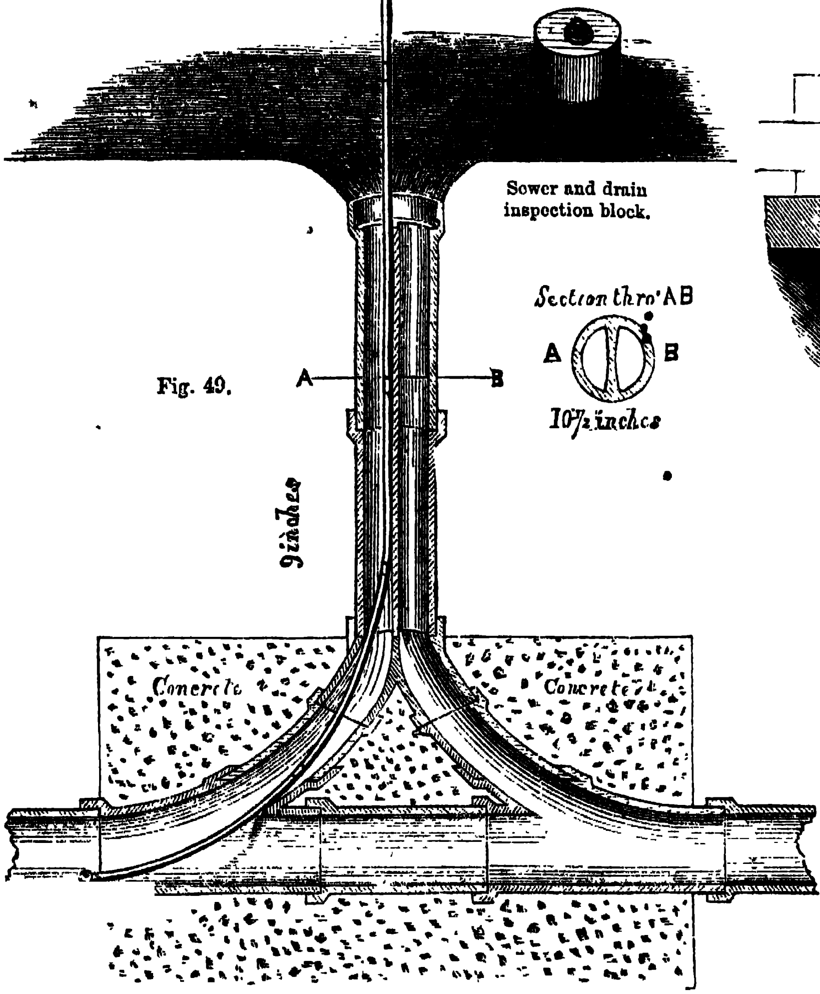

Cane for removal of obstructions.
Sewer and drain inspection block.
Section thro' AB
A
B
10½ inches
A
B
9 inches
Concrete
Concrete

Fig. 49.

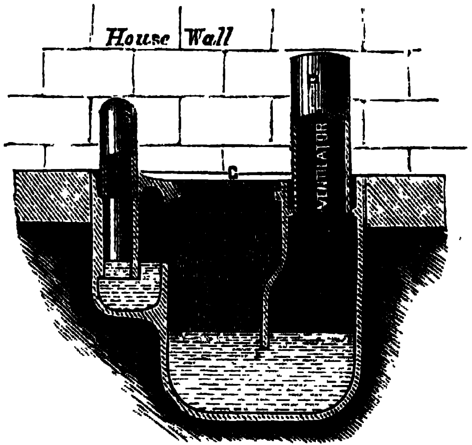


Fig. 47.

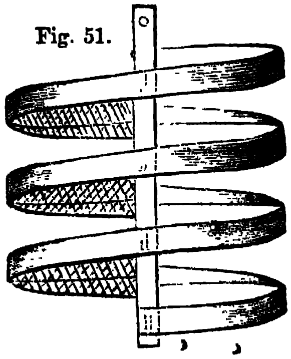


Fig. 51.

large quantities. The oxygen of the air is the great vivifier of nature. The deadly emanations given off by decomposing matters are in what is called a low state of oxidation—that is, they contain a comparatively small proportion of oxygen; combine them with, or force them to take up more of this purifying element, and the point is gained—that which perhaps an instant before would have proved most hurtful if breathed, becomes now entirely resolved into comparatively harmless combinations. Now, as charcoal contains within its pores a very large proportion of oxygen, amounting to rather more than eight times its bulk, its efficiency as a disinfecting agent is thus satisfactorily proved, not only in theory, but also practically by experiment."

There are many ways of employing it. In one of our previous papers we gave a sketch of a patent trap invented by Mr. Cottam, the engineer, where the ventilator at the ground level was covered or protected by a layer of charcoal; and we now proceed with some sketches of another adaptation of the same principle. Referring to the earlier part of our article, recommending the adoption of a ventilating pipe, we now show how the gases passing up this pipe may be thoroughly deodorised by the intervention of a series of shelves containing charcoal (Fig. 50).

In this A is the upcast pipe from the drain, B the ventilator containing the shelves, and E the pipe that discharges the deodorised gases into the open air. Those trays may be replaced by a spiral tray, as in the sketch below (Fig. 51), known as Latham's patent. Fig. 52 shows the outside appearance of the disinfecting apparatus when fixed complete.

The above illustrates the general principle, which is capable of many modifications. In a large pauper asylum recently erected at Wandsworth the object was specially provided for by means of flues constructed in the body of the building, and carried up to the highest point of some angle towers, that form a marked feature in the elevation; at the topmost level boxes of charcoal were provided, through which the sewer gases, thoroughly disinfected, were allowed to escape into the open air.

The same result may be attained by various other chemical means, into which our space will not allow us to enter in the present paper; but in a later branch of the subject, the ventilation of sewers as distinguished from house-drains, we may probably deal with the question in rather fuller detail.

Whenever from circumstances the outfall of the drainage of any particular district takes place during only a few hours of the twenty-four, ample provisions for the ventilation of house drains are most especially requisite. We may instance some of the low-lying districts adjoining the Thames, for which, when the tide is high, the sewers are what may be called water-locked for perhaps more than twelve hours out of the twenty-four; and the recent shortcoming so prominently brought before public notice in the case of Scarborough is another exemplification of a similar state of things. Another point worthy of attention is the fact that the greater portion of sewage water, properly so called, passes through the drains during the day only; the quantity passing during the night being comparatively small; while the rainfall only is, of course, about equally divided as a matter of average during the twenty-four hours; although storm-waters, as they may be called, at certain times of the year fall in such quantities within sometimes the space of an hour or two as entirely to overcharge all ordinary systems of drainage. These, however, are not much to be feared upon sanitary grounds, as their first action is thoroughly to flush the drains, and wash away the sewage properly so called, the surplus or overflow consisting for the most part of rain-water only, which has to find its way by degrees, when the drains are overcharged, through the adjacent ground.

We need hardly say that when any system similar to Moule's is introduced, the remarks and illustrations of this paper do not apply to the case with equal force, although even then, the necessary constructions for the removal of rain, surface, and subsoil water are all the better for due provision being made for their thorough ventilation.

In our next paper we shall take up the question of the construction of sewers; giving a certain amount of attention to village and suburban districts, and probably a few particulars as to the last improvements in construction, as adopted in our recently completed metropolitan system.

BIOGRAPHICAL SKETCHES OF EMINENT INVENTORS AND MANUFACTURERS.

XXXII.—BENJAMIN ROBINS.

BY JAMES GRANT.

This celebrated English mathematician, philosopher, and experimentist was born at Bath in the year 1707. Although his parents, who belonged to the Society of Friends, were unable to give him much education, yet so strong was the inborn vigour of his own mind, that he taught himself various branches of knowledge, and more particularly the science of mathematics, of which his friends wished him to become a teacher, and to settle in London. With this view he travelled to the metropolis, carrying with him a letter of introduction to Dr. Pemberton, who conceived and expressed a very high opinion of his scientific acquirements.

To prepare himself more fully for the important office of tuition, he perused the works of the most eminent mathematicians, and while in the course of these studies he was led to demonstrate the last proposition of Sir Isaac Newton's "Treatise on Quadratures," which appeared in the *Philosophical Transactions* for the year 1727.

In the year following Robins published "The Present State of the Republic of Letters," in refutation of the dissertation of John Bernouilli on the laws of impact in moving bodies. The paper referred to was the production of John, brother of James Bernouilli, the famous mathematician of Basle, and it had lost the prize offered by the Academy of Sciences in 1726.

Having now brought himself before the world of letters as a mathematician, Robins relinquished the peculiar costume of the Society of Friends, and began to take pupils; but the great activity of his mind, however, did not permit him to be satisfied with his theoretical studies; and singularly enough, for one who had been reared in the peaceful tenets of Quakerism, he began a series of the most elaborate experiments in gunnery, with the view of establishing the influence of the resistance of the air upon projectiles. He also directed his attention to the various branches of a great art that was as yet in its infancy—civil engineering; and he made several tours in the Low Countries for the purpose of studying fortification.

In 1734, on his return to London from one of those tours, he found the scientific world in a state of commotion occasioned by the publication of the "Analyst," by the learned Dr. George Berkeley, Bishop of Cloyne, in which that ingenious author attempted to refute the Newtonian doctrine of fluxions. He further styled Dr. Halley an "infidel mathematician," and endeavoured to prove that mysteries in faith were unjustly objected to by mathematicians, who, he thought, admitted much greater mysteries and even falsehoods in science, of which he affirmed the doctrine of fluxions was a pregnant example. This occasioned a long and angry controversy between the bishop and many men of science. Robins requested special permission to devote himself to a refutation of the charge, and accordingly in 1735 he published "A Discourse concerning the Nature and the Certainty of Sir Isaac Newton's Method of Fluxions, and of Prime and Ultimate Ratios;" but some exceptions that were taken to this production, even by the adherents of the fluxionary system, led him to publish more papers on the same subject.

The year 1738 found him defending Newton against an objection in the "Matho" of Andrew Baxter, the eminent Scottish metaphysician. In the following year he published his remarks on Leonard Euler's "Mechanica sive motus scientia analytice exposita," which had been published at Petropoli; a paper on Smith's "System of Optics," and another on Jurin's "Distinct and Indistinct Vision," published at the end of the last of these works. But the talents of Robins were not restricted to their proper sphere of natural philosophy and mathematics; he took a keen part in the angry and bitter politics of the day, and issued three pamphlets on the public affairs of the times, which created a great sensation.

The first of these was entitled "Observations on the present Convention with Spain;" the second was "A Narrative of what passed in the Common Hall, and the Citizens of London assembled for the Election of Lord Mayor;" and the third was an "Address to the Electors and other Free Subjects of Great Britain, occasioned by the late Succession; in which is contained a Particular Account of all our Negotiations with Spain, and its Treatment of us for above ten years past."

These pamphlets were all anonymous; and the first and last were so pungent that they were currently believed to be the production of Mr. Pulteney, who was then the active opponent of Sir Robert Walpole, and when the latter was ultimately defeated by the opposition, Robins was actually chosen secretary to the committee of the House of Commons appointed to examine into the conduct of that minister!

In 1742 he published his "New Principles of Gunnery," a work of which an account was given by himself in the *Philosophical Magazine* for the same year. In this book he concludes, from experiments he had made, that the force of gunpowder, at the instant of its explosion, is the same with that of an elastic fluid of a thousand times the density of common air, and that the elasticity of this fluid is proportional to its density, and in illustration proposes the following problem, which refers, of course, to *round* shot:—

"The dimensions of any piece of artillery, the weight of its ball, and the quantity of its charge being given, to determine the velocity which the shot will acquire from the explosion, supposing the elasticity or force of the powder at the first instant of firing to be given." In the solution of this important problem he assumes the two following principles:—

"1. That the action of the powder ceases as soon as it is out of the piece.

"2. That all the powder of the charge is fired and converted into an elastic fluid, before the shot is sensibly moved from its place.

"These assumptions, and the conclusions above mentioned, make the action of fired gunpowder to be entirely similar to that of air condensed a thousand times, and from thence it will not be difficult to determine the velocity of the shot." Robins also gave an ingenious method of determining by experiments the velocity with which any shot moves at any distance of the piece it may be discharged from, by the adoption of a pendulum, a description of which would occupy too much space. By this he ascertained that the velocity of the common cannon-ball was 1,641 feet per second, when fired point blank. His work also combined an introductory history of modern fortification, with the invention of gunpowder, and the whole theory of gunnery.

In consequence of a paper having been published in the *Philosophical Transactions* against some of his opinions, he was led to submit to that learned body several treatises on the resistance of the air, and to exhibit the experiments on which they were founded, in the years 1746 and 1747. For this he was presented with the gold medal of Sir Godfrey Copley. When Lord Anson returned from his voyage round the world, the Rev. Richard Walter, chaplain of the *Centurion*, had proceeded to draw up a history of the expedition, but it was deemed advisable to have the whole rewritten by Robins. It appeared in 1748 with Mr. Walter's name on the title-page. The work went, however, through several editions, and the fifth was corrected by Robins himself in 1749.

In the same year he published in London "An Apology" for the defeat of the King's troops by the Highlanders under Prince Charles Edward at Prestonpans; and this paper formed a preface to "The Report of the Proceedings and Opinion of the Board of General Officers on the Examination into the Conduct of Lieutenant-General Sir John Cope."

Through the influence of Lord Anson opportunities were afforded him of making further experiments on his favourite subject of gunnery and all warlike projectiles; and through the same kind influence he procured for the Royal Observatory at Greenwich a second mural quadrant and other instruments. The services of Mr. Robins in science and politics had now become so prominent and so numerous, and his general reputation was so high, that the ministry of George II. became desirous of bestowing upon him some lucrative appointment. It was accordingly put in his option whether he would go to Paris as one of the government commissioners for adjusting the then vexed question of the limits of Acadia (the name originally given by the French to Nova Scotia and New Brunswick, and, indeed, to the whole of the North American Continent from the 40th to the 46th parallel), or to be the Engineer-General to the East India Company, the ruinous condition of whose forts required an able engineer to put them in a state of defence; and the somewhat military predilection of Robins, fatally for himself, induced him to prefer the latter. A regular corps of military engineers did not at that time exist in Britain, though officers termed civil engineers had occasionally been attached to the Ordnance Department from 1627, when the name of Thomas Rudd first appears on the list; and the first colonel-commandant appears in 1802.

Provided with a complete set of astronomical and other instruments for making scientific observations and experiments in the East, then a remote land and but little known to us, Robins, full of enthusiasm and ardour, sailed from London on Christmas Day, 1749, and after a hazardous and rough voyage he landed at Madras on the 13th of July, 1750. There he immediately set about the preparation of plans for the complete repair of Fort St. George, and Madras, which had been taken by the French in 1744, and had just been restored to us by the peace of Aix-la-Chapelle. The constitution of Robins was totally unsuited to the climate. In September he was attacked by fever, and though he recovered partially from its effects, he was unable to work or study, and fell into a languishing condition, which continued until the 29th of July, 1751, when this eminent English philosopher expired. thus he had only gone to India to find a grave in the Carnatic in the forty-fourth year of his age.

By his will he bequeathed the publication of his mathematical works to his friends Dr. James Wilson and Martin Folkes, and they published them in three vols. octavo, in 1761. His "New Principles of Gunnery" was translated into several languages; and they appeared in German from the pen of the illustrious Leonard Euler, accompanied by a copious commentary. This work was afterwards translated into English in 1779 by Mr. Hugh Brown. Besides the books already referred to, Benjamin Robins wrote a paper on the height to which rockets will ascend, which appeared among the *Philosophical Transactions* for 1749.

TECHNICAL DRAWING.—LXXII.

DRAWING FOR BRICKLAYERS.

PLAIN BRICK ARCHES.

PLAIN or rough arches are those in which none of the bricks are rubbed to suit the splay. Hence the joints which are quite close to each other at the intrados, are necessarily wider towards the extrados of the curve.

When the radius of curvature of a brick arch is small—that is to say, when it is under or not exceeding three or four feet—the best arrangement is to build two or more four-inch concentric brick arches over each other until the whole necessary thickness is obtained: each of these successive rings being built as an independent arch, without attempting to bond the upper or larger arch of any two into that which is immediately below it.

Fig. 588 represents a part of a semi-circular arch of this description supposed to have a span of 6 feet, and consequently a radius of curvature of 3 feet, and consisting of four concentric four-inch-thick arches combined into one arch of two bricks in thickness.

The bond of brickwork used in any arch is always judged by the appearance which it exhibits to the eye of the spectator looking up towards the intrados or lower surface of the arch. Hence in the present illustration, since all the bricks used, if so viewed, would have the appearance of stretchers, the whole arch is said to be built with stretchers, or in "stretching bond," being composed entirely of whole bricks laid as stretchers, excepting only at the two extremities of the arch, where each alternate voussoir is a bat or half-brick, without introducing which bricks composing a four-inch arch could not be properly bonded together.

The reason for building an arch of small radius with a series of four-inch rings, and without attempting to bond the successive parts into each other, is sufficiently obvious. The joints of such an arch diverge so very rapidly from the intrados outwards, that if it were built otherwise the brickwork would not be sufficiently compact, for at the upper part of the arch the bricks would be separated to an extraordinary and inconvenient degree. In some cases, headers—*i.e.*, whole-length bricks—are inserted at certain distances—that is, where three or four or more bricks of the inner ring cut in with four, five, or more bricks of the outer ring.

Fig. 589 shows the unfavourable effect which would be produced by building an arch of a small radius in the manner just alluded to. From this it will be seen that if the span of the arch were 3 feet, the external spaces between the bricks of a two-brick-thick arch would be 2⅛ inches. These joints, if filled entirely with mortar, would be prejudicial to the solidity of the work; and if filled with harder materials, such as pieces of stone, slate, or fragments of brick, the arch would have a motley and unseemly appearance.

It must be pointed out to the student that although the bricks in rough arches are said to radiate, it is their *centre lines* which do so, not their sides; the ends of the bricks are parallelograms placed on their narrow ends, and it will be readily seen that their sides could not converge to the centre. This cannot be clearly represented in Fig. 588, and therefore a few bricks are drawn on an enlarged scale in Fig. 590.

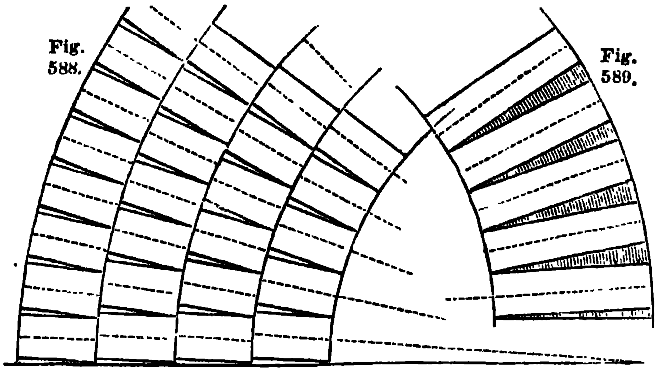


Fig. 588.
Fig. 589.

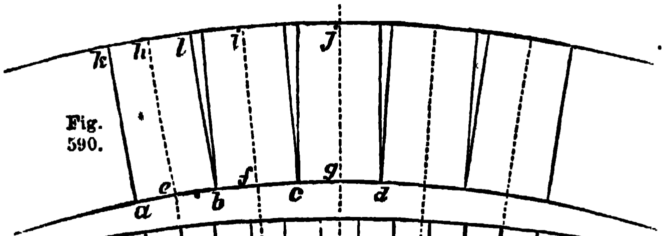


Fig. 590.

To draw a rough arch, having described the two arcs between which the ring of brickwork is to be contained, set off on the *inner* arc the true widths of the edge of the bricks of which the arch is to be composed, as *a, b, c, d*; find the middle of each of these spaces, as *e, f, g*; and through these draw lines converging to the centre from which the arcs are struck; then the sides of the bricks, *a k, b l,* etc., will be parallel to *e h, f i, g j,* etc.

In drawing gauged arches, the thickness of the separate bricks are set off on the *outer* arc, and from the divisions lines are drawn to the centre; the wedge form is thus given to the bricks, the inner end becoming narrower than the outer.

As the radius of the curvature of an arch increases, the joints diverge less rapidly, so that the use of nine-inch arches formed with heading bricks ceases to be objectionable.

For example, in a semi-circular nine-inch arch of 12 feet span (whose radius of curvature is of course 6 feet) the radius of the curve of the intrados is to its radius at the extrados as 6 feet to 6 feet 9 inches, or as 1 to 1⅛. Hence the joints at the upper part of the curves will not exceed one-eighth part of the width of an arch-brick, or about five-sixteenths of an inch, which is neither inconvenient nor unseemly. If the radius of curvature be greater than 6 feet, the width of joint at the extrados of a nine-inch arch will be further diminished, so that in a semi-circular arch of 18 feet span it will scarcely amount to so much as one-fifth of an inch.

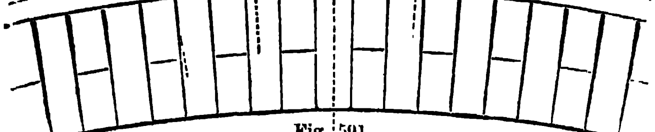


Fig. 591.

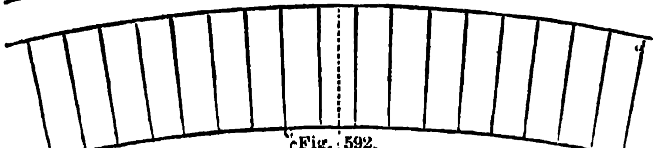


Fig. 592.

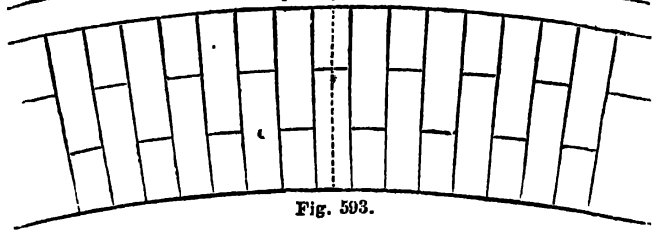


Fig. 593.

A nine-inch brick arch may be built according to three different methods—

1. The bricks composing the voussoirs may consist partly of headers and partly of stretchers, built according to Flemish bond. Fig. 591 represents the end elevation or section of part of an arch of this description, supposed to have a radius of curvature of 9 feet.

2. The bricks composing the voussoirs of a nine-inch arch may consist of headers and stretchers built according to English bond. In this case the extremities of the arch have the same appearance as in the former arrangement, which is likewise a correct section of this method. But the appearance of the brickwork of the intrados of this arch is different, being similar to common English bond in the face of the wall.

3. The bricks composing the voussoirs of a nine-inch arch of the same span and curve may be laid all heading bond, so that the transverse section of the body of the arch will everywhere be that represented in Fig. 592.

In an arch of this description no false headers are used, nor are stretchers used anywhere, excepting at the extremities of the arch, where they are introduced in alternate voussoirs for the sake of breaking the bond, the same being done in the face of a wall of this description.

Hence in a nine-inch arch built all in heading bond the section is as in Fig. 592, but the end elevation is the same as that of an arch of equal thickness built according to Flemish or English bond (see Fig. 591).

OF PLAIN ARCHES ONE BRICK AND A HALF IN THICKNESS.

In this case, if the radius of the curvature do not exceed three or four feet, such arches would of course be built in three concentric four-inch arches, according to the rule already laid down. In arches, however, of greater radius, such as from six to eight feet, the usual method is to build the voussoirs in alternate courses of headers surmounted by stretchers, and stretchers surmounted by headers from one side of the arch to the other.

Fig. 593 represents this arrangement, which is not only an end elevation, but a correct section of the arch throughout.

OF PLAIN ARCHES, AS APPLIED TO COMMON BRICK BUILDINGS.

The plain or rough arches used in common buildings are generally concealed from view. They are applied under the following circumstances:—

1. To cover the aperture of an external door or of a window in addition to the ornamental arch, which is generally a mere shell, as has already been explained.

When the arch of an external door or of a window is a semicircle or segment, the rough internal arch follows the same form, and no woodwork is used in aid of such an arch.

But when the ornamental arch of an external door or of a window is a straight or flat arch, pieces of timber, called *lintels*, are laid over the remainder of the aperture in rear of the ornamental arch, and in the internal doors of a building these lintels cover the whole space with a bearing of about 1 foot or 18 inches at each end.

In this case a rough arch is also usually thrown over the aperture above the said lintels, in order to relieve them of their weight of the superincumbent brickwork.

The annexed cut (Fig. 594), repeated from "Building Construction," represents the mode in which such rough arches should be formed in aid of a lintel. The intermediate space between the bottom of the arch and the woodwork is filled with bricks and bats cut to the curve and laid in mortar.

2. Rough arches are used for fireplaces.

In this case a bar of iron from ⅛ to ¾ inch thick, and usually not less than 4 inches wide, is prepared beforehand suited to the form of the arch, and extending across the chimney-breast from one side to the other, so that it comprehends the width, not only of the proposed arch, but also of the piers on each side or of part of them.

Upon this bar, the ends of which are turned back in contrary directions, and which is technically called a *turning bar*, the arch is built, which bar, however, is not removed like common centering, but remains permanently in the same place in aid of the arch.

3. Rough arches are used beneath the hearths of fireplaces.

It has been explained in "Building Construction" that no woodwork is admissible below a fireplace, and that joists extending in that direction are framed into a transverse piece of timber called the *trimmer*, which is usually two feet distant from the chimney-breast, in buildings of importance. Between this trimmer and the bottom of the fireplace a four-inch segment brick arch, rather less than a quadrant, is constructed, which rests on one side against the upper part of the trimmer; and this is the vertex of the curve. On the other side, which is on a level with the bottom of the trimmer, it springs with a skewback from the wall: the space between the top of the arch and the under surface of the hearthstone is filled in with brickwork. This arch has been illustrated in Lessons on "Building Construction" (TECHNICAL EDUCATOR, Vol. II., page 5).

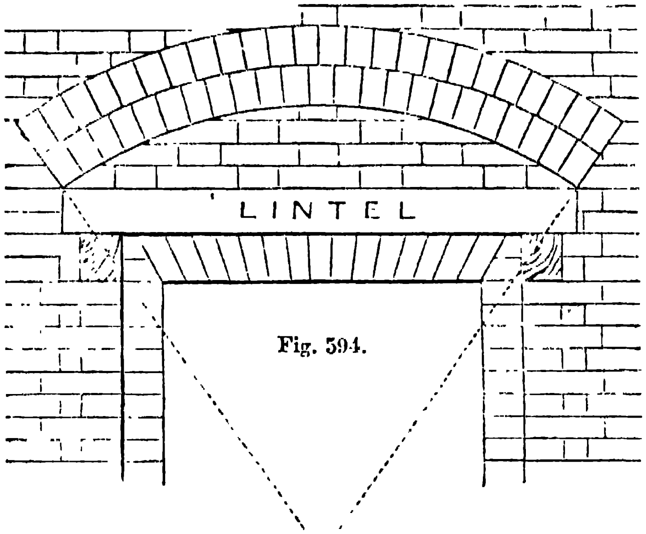


Fig. 594.

4. Rough arches are used beneath the entrances of all buildings having an area to the basement storey. In this case a leaning arch is used, which on one side abuts against the area wall, while on the other it leans against the wall of the building. Above this arch, and extending partly across the area, and on the same level with the pavement, or sometimes one step above it, large flag-stones are laid; beyond which a flight of two or three steps, at least, usually leads from that level to the entrance-door of the building. Fig. 587 (page 384) exemplifies this arrangement. These arches are technically termed *bridgeways*.

PHOTOGRAPHY.—XI.

By J. C. LEAKE.

PHOTO-LITHOGRAPHY.

ALTHOUGH the process of printing in carbon or pigments, described in our last paper, has to some extent superseded the photo-lithographic process, the latter is of so important a character, especially when copies of maps or line-drawings are required, that a knowledge of the process is essential to the practical photographer. We will therefore devote this paper to the consideration of the subject, merely observing that, beside the photographic part of the process, it is desirable that the operator should possess some knowledge of the system of ordinary lithographic printing. An ordinary lithographic press will be required, with stones, inking-rollers, and suitable ink.

One of the most important points, in order to ensure success in photo-lithographic work, is the production of a negative of exceeding density and clearness. The lines must be perfectly sharp and transparent, the smallest trace of fog being fatal to anything like clear delineation. In order to ensure these conditions some variations from the ordinary photographic processes are required, and these we will proceed to describe. The collodion should be one which adheres well to the glass, and should be rather old. Unless it works perfectly clear in the shades it should be mixed with a little dilute tincture of iodine, made by dissolving iodine in pure alcohol. Enough of this may be added to bring the mixture to a dark sherry colour. It must also be allowed plenty of time to settle, and be perfectly clear. The nitrate bath should be of full strength—from thirty-five to forty grains of silver to the ounce, slightly acid, and perfectly clear and clean. The exposure should be enough to secure a tolerably rapid development, as unless the image can be obtained upon one application of the developer there is danger of fogging the lines and destroying their sharpness. The best developing solution is a fifteen-grain solution of sulphate of iron with the same proportion of acetic acid, to which is added as much alcohol as may be needed, in order to make it flow evenly over the plate. As soon as the lines of the drawing are visible the plate should be well washed and slightly intensified in the ordinary way with pyrogallic acid solution and nitrate of silver.

The negative should then be fixed with hyposulphite of soda, and thoroughly washed. It should now be carefully examined in order to ascertain that the image is sharp, well-defined, and free from fog. The lines should be perfectly sharp, and without the slightest trace of deposit. This being the case, the negative may be intensified by pouring over the surface a saturated solution of bichloride of mercury, washing, and afterwards darkening with a very dilute solution of hyposulphite of soda. Should the negative not be sufficiently intense this operation may be repeated, when the film should be very thoroughly washed in order to remove all trace of the hyposulphite.

It should be borne in mind that for copying drawings and maps by this process the negative must be perfectly opaque in the lights and as perfectly transparent in the shadows, as upon these two conditions the whole success of the work will depend. The negative should be left unvarnished. The next operation is the preparation of the photo-lithographic paper. For this purpose the ordinary Saxe paper will answer very well, as will also that known as bank-post. The gelatine is prepared as follows:- Take three ounces of fine gelatine, and dissolve in forty ounces of hot water. While still hot filter through warm wet flannel or fine muslin. For use the gelatine must be kept in a fluid state by means of heat. If used in a dish the first must be placed in a second and larger vessel, filled with hot water. The surface of the fluid gelatine should be skimmed with a slip of paper, and the sheets to be coated, after being cut to the requisite size, be floated upon the surface, taking the utmost care to avoid air-bubbles. When coated the paper may be suspended until dry. Another and excellent plan is to procure a sheet of glass of the required size, and having immersed it in warm water, to place upon it the sheet of paper to be coated, and which has also been damped in water of the same temperature. The sheet should then be pressed down evenly upon the glass, by means of the india-rubber "squeeze" mentioned in our last paper on carbon printing, and the superfluous moisture removed from its surface. While still warm the melted gelatine may be poured over the surface, and the sheet coated by tilting the plate precisely as if coating a plate with collodion. It should then be placed perfectly level upon a suitable stand, and allowed to set, which it will do in a few minutes.

The sheet may then be slipped off and suspended to dry. This is an excellent plan where a few sheets only are required, as a small quantity only of gelatine is employed, and there is little or no waste. Paper thus prepared resembles that which has been albumenised, as it is insensitive, and will keep an indefinite time in a dry drawer or box.

The sensitising of this paper is effected by immersing it in a saturated solution of bichromate of potash. It should remain in this for a few minutes, and after removal be thoroughly dried, when it will be ready for exposure to light under the negative. As we before remarked with respect to this part of the carbon process, it is well-nigh impossible to give any definite rule as to the time required, but with an average light about five or ten minutes will be necessary.

The next operation is that of inking the impression, and is performed as follows:—(For this purpose the lithographic press will be required.) Take a clean polished lithographic stone, and charge it by means of the litho-roller with a smooth and perfectly even coating of litho-transfer ink. The thickness of the ink will cause a considerable variation in the result, and can only be determined by practical experience. The print should then be allowed to soak in cold water for about a quarter of an hour, when the excess of moisture should be blotted off, and the paper with the impressed image placed, gelatine side downwards, upon the inked stone. The whole may now be passed through the press in the usual manner, using rather less pressure than would be required in the ordinary process of lithographic printing. When removed from the stone the print will be found to have received a uniform coating of ink, and the more uniform this coating is the sharper and better will be the final result.

In order to remove the superfluous ink the print should be well soaked in cold water. A solution of gum-arabic should then be prepared of rather more than the average strength, and to this should be added a little weak solution of nitric acid. This mixture should be applied to the print with a soft sponge, when it will be found that the ink may be readily removed from all those portions of the surface upon which the light has not acted, while it will adhere tightly to those which have been exposed to its influence, thus leaving an impression in lithographic ink upon the surface of the paper. All that now remains to be effected is to thoroughly clean the lights by means of careful sponging with clean gum-water, after which the transfer print is complete, and may be laid by to dry. At this stage of the process the question of success or failure may easily be determined. If it should be found that the finer lines which lie close together, or the angles formed by the crossing of the lines are filled up with ink and are not quite sharp, clean, and well-defined, then there has probably been too much ink upon the stone; while if, on the other hand, the lines are clean and well defined, but wanting in vigour and in sufficient body to transfer themselves well to the stone, the defect will probably arise from the inking having been insufficient. This latter defect, however, is seldom met with in practice. The ink should leave the paper quite freely and easily as well as completely; and when this is not the case, and if there should remain upon what should be the unaltered portions of the film traces of ink in patches over the drawing, in all probability light has reached the paper either through a defective negative or from some carelessness during the process. It cannot be too strongly impressed upon the operator that the bichromated gelatine is exceedingly sensitive to light, and that in all processes wherein this substance is employed the utmost care must be exercised in order to protect it from any extraneous action. In fact, it should be as carefully shielded as a sensitive collodion plate. Should the lines appear broken, and betray an inclination to leave the paper, it is most likely that the exposure to light has been insufficient to completely alter the character of the gelatine, which is consequently still partially soluble. It frequently happens that, while the coarser lines are bold and vigorous, the finer ones are weak, ragged, and partially obliterated. This mostly arises from an imperfect negative. If the intensification has not been carefully performed, a very fine deposit, almost invisible except to the most careful observer, is formed in the finest lines, and this is quite sufficient to prevent a proper action upon the gelatine.

It may not be out of place here to remark that the process above described is not suited for the production of pictures in half tint, except the gradations are produced by lines or dots. For instance, a line-engraving or a manuscript may be perfectly reproduced; but an ordinary photograph would be utterly useless if copied by these means. Many attempts have been made in this direction, and some of the results have been most promising, but no process has, up to the present time, been uniformly successful. These remarks are not intended to deter the operator from experimenting in this direction, but simply to prevent his attempting to copy pictures which, from their unsuitability to the process, would probably lead to failure and disappointment.

In conclusion, we would observe that this process is based upon the fact that, while gelatine in its normal state—that is to say, unacted upon by light—is absorbent of water and soluble, it becomes after that action insoluble and non-absorbent. Thus after the exposure under a negative the print is wetted, and water is absorbed in all the unaltered portions, while those which have been exposed remain dry. The fatty ink employed is consequently resisted by the wetted parts of the surface, while it is retained by those which remain dry; thus forming the print which is transferred to the stone. There is often little or no relief in the impression, and the print is formed through this attraction and repulsion of the fatty ink alone.

We have not thought it necessary to describe the transfer of the print to the lithographic stone, as that is effected precisely as in the well-known lithographic printing process; but we should advise the operator to endeavour to see the transfer process performed before attempting to effect it for himself, as he would learn more in a few minutes from actual inspection than could possibly be acquired from mere written instructions, however elaborated.

MAP AND PLAN DRAWING.—III.

By C. C. King.

METHOD OF CONSTRUCTING CHARTS—THE WORK DONE ON SHORE—THE WORK DONE ON THE WATER—ABBREVIATIONS AND CONVENTIONALITIES USED IN DELINEATING CHARTS.

The careful construction of a map of a large territory, conducted as we have described, presupposes an advanced state of civilisation in the country thus delineated. Experienced workmen, a population not adverse to the survey, the assistance to be derived from government or civil authorities, are all essential to accurate work. The necessity for it must be recognised by the people, so that the different stations may remain undisturbed during the operations; and the necessity or value of such a map presupposes an area well populated and cultivated, and with an abundance of large towns and villages, the communications between which are numerous enough to render movement practicable and inspection of the details possible.

But beyond the limit of such countries, there is much to be discovered and mapped, which is useful and necessary to the inhabitants of the civilised districts. An accurate description of the coast-lines and land adjacent to the sea are requisite for the prosecution of commercial enterprises, as well as to enable vessels to move with confidence from point to point. For this purpose charts or hydrographical maps are constructed, and these rarely go beyond the immediate coast-lines of the islands or continents. In barbarous countries a survey beyond this limit would be practically impossible, not merely because of the opposition of the inhabitants, but more especially because of the uncultivated nature of the land rendering an extensive triangulation a matter of extreme difficulty, even if it were permitted by the natives, or if it were to the interest of the nations concerned in knowing the character of the country, to provide the means for carrying out the work. In these cases the coast is alone depicted, and the interior of the area either left a blank, as is usually done with the African continent, or if it cannot be approximately filled in by local information or even maps, which would be done in China or any semi-barbarous realm, some few points are determined by their latitude and longitude, and as much of the neighbourhood sketched in somewhat roughly as time and opportunity will permit.

The chart, however, to be useful and reliable must be carefully completed, as the information it has to give can be readily procured; and as moreover the value of a chart to a vessel depends entirely on the faithfulness of the representation of the coast itself, the accuracy of the soundings taken, and the exactness of the position of all the remarkable features given by their latitudes and longitudes, as well as their respective distances and relative bearings one from the other, must be accurately ascertained.

Chart-making is simply the extension of the land survey of a great country, such as we have imagined, to more distant parts, thus completing the delineation of the remainder of the earth's surface; only in these maps we deal with a bare outline of the foreign countries or an imperfect filling-in of the interior rather than with the careful, laborious delineation of every feature, physical or otherwise, which results from a measured base and a system of triangulation. Some knowledge of astronomy is absolutely required by the operators in this species of surveying, as the distances from one principal point to another can only be determined by their latitude and longitude if far apart.

Instruments have to be constantly adjusted or corrected by astronomical observations, and a rough practical acquaintance with the positions and movements of the heavenly bodies, and the causes leading to variations both of compasses and other instruments, is indispensable.

The construction of a chart, then, divides itself into two parts—first, the work done on shore; second, the work done on the sea. The former is a repetition of an ordinary survey as far as practicable—that is, a point is first astronomically fixed by its latitude and longitude, either by means of a sextant and the artificial horizon, or by means of a small transit instrument. The sextant is a metallic frame constructed in the form of a segment of a circle, the arc of which is graduated in 140 degrees. A movable arm, which is pivoted at the centre of the circle of which the instrument forms a part, extends to the graduated arc, and is capable of being retained in any given position by a clamping-screw. It is furnished at its upper or pivoted end with a mirror, accurately fixed by the maker so as to be always perpendicular to the plane in which the arm moves and parallel to the arm, thus partaking of its movement; and at its lower extremity on the arc it has a vernier for reading minutes and seconds of an angle measured, with a small motion-screw for careful adjustment, and a microscope for accurate observation. A telescope is fitted in a socket at one side of the instrument, and on the other side of the frame is fixed a small glass called the horizon-glass, the lower half of which is a mirror, and which is so adjusted that its plane is perpendicular to that of the sextant, and parallel to the movable arm when it is fixed at zero. Coloured glasses are provided, to be used in taking observations of the sun. In using it the telescope is screwed in, and while one of the two objects between which the angle is to be taken is viewed through the upper or transparent portion of the horizon-glass, the movable arm of the instrument is moved until the reflected image of the second object is thrown from the movable on to the fixed mirror, and the two objects made by a slight motion of the hand to coincide. The arm is then clamped, the exact coincidence of the objects determined by the small motion or "tangent" screw, and the reading, which is the angle between the two points, taken. The artificial horizon is a small flat iron vessel to contain mercury, and is protected from disturbance from wind or other causes, by a glass shade or cover By it the altitude of the sun at any given time can be ascertained, the observer bringing the image of the sun reflected in the mercury, and seen through the unsilvered portion of the horizon-glass, in close juxtaposition with the image reflected on the movable mirror of the arm, and thence on the lower portion of the horizon-glass. It must be remarked whether the upper or lower limbs of the sun have been brought into contact, and having the time of observation noted down, the latitude can be determined by calculation.* The longitude is, of course, ascertained from the chronometer, by means of which the difference in the time at the station and at Greenwich can be ascertained. The transit instrument is only used in observations where time and opportunity are afforded for the work. It is simply a telescope mounted on a frame, which must be carefully adjusted in the plane of the meridian, and affords the means of obtaining the exact time at which certain planetary bodies cross the meridian, and their distance from the zenith. Thus the longitude can be obtained, or even, by arrangement, the latitude.

From the point thus determined a survey of as extensive a nature as possible would be made. A base-line, measured some few times to ensure approximate accuracy, would be fixed, and from it by triangulation the distances of the more prominent objects would be calculated; but as any materials at hand, such as a deal rod, or a "lead line" used in taking soundings, would be used to effect the measurement of the base, the most important part of any survey, the results arrived at would be only approximately true. The work done on shore, then, is a rough, generally hasty attempt at delineation by the ordinary principles of surveying, a theodolite being employed when practicable for measuring the angles, and in other cases the sextant.

The work done on the sea, which is the more important of the two divisions of the chart, obliges us to use different means of providing our data for calculation, though the application of these data is in principle the same as in a land survey. We are unable to measure any base upon the sea from which to determine the relative positions of our main points, and we have further to ascertain a new series of facts, that do not, of course, enter into our previous work—the depth of water, and the size and character of rocks or shoals which may be concealed beneath the surface of the sea, or be only apparent at certain times of tide.

The instruments required, therefore, are the chronometer to calculate longitude, and which is to be corrected by "lunar distances,"* or other astronomical observations, for its rate—that is, its variation from day to day, and its error of rate, or the error in that variation; the sextant, which has been described above; the ordinary mariner's compass for ascertaining magnetic bearings, which has to be corrected for its variation by taking the true bearing of the sun at noon, and then calculating the variation according to fixed laws; and lastly, the "sounding lead," a line twenty-five fathoms long, furnished with a long leaden weight hollowed at its base, so as to contain a little grease, to which sand or pebbles, showing the character of the sea-bottom, may adhere.

The method of procedure is the same as in a survey on shore. The surveying vessel anchored, and with its true place found by observation, forms the principal point to which all others are referred. A series of boats, each containing a sounding line and an officer for taking the observation, diverge in different directions from it, and at the requisite distances from the ship take angles between it and each other, thus forming a rough series of triangles, which should be as nearly as possible equilateral. These distances are ascertained in two ways: either by reading the angle subtended by the mast of the ship from the truck to the keel, and from prepared tables finding the base of the right-angled triangle, which is the distance required, or by calculating it from the velocity with which sound is known to travel. For this purpose those boats which proceed on a course as nearly as possible at right angles to the direction of the wind are selected, and guns are fired from the vessel to give the necessary data, pocket chronometers or stopwatches being employed to determine with all possible accuracy the intervals of time that elapse between the moment when the flash of the gun is seen and the sound of the report is heard by the observer. If the boats be large enough, one or more may carry small guns, which, if fired with a high elevation with shot, will give a report that can be heard a considerable distance; and thus a series of results may be obtained, which will give a satisfactory and tolerably correct mean. If the weather be calm, and the area to be examined extensive, beacons constructed of small barrels, with a staff and distinguishing flag, may be anchored at convenient points; and these will form intermediate stations of greater comparative accuracy than can be obtained from the boat, influenced as it would be by tide or wind. Thus the data on which the triangles are constructed are given by the position of the ship, the true "bearing" of the boats, and the distance calculated by sound; while the nature of the bottom is arrived at by a series of soundings taken on any given "bearing" at intervals of about ten minutes, when also any alteration in the character of the material composing the bottom is carefully noted.

Thus the area of the shoal, if it be one, is carefully marked out, and the same operations are carried on in the case of a bay, a river, or an inlet; the only difference being that the observations taken by the boats are corrected, and the number of intermediate points increased, by taking the magnetic bearings of any number of the most striking points on the coast (which may be further corrected by astronomical observation), and where also observers may be landed to take a further series of angles, and sketch the nature and form of the coast-line. Beacons are erected at these places when practicable, and even rocks may have white marks painted on them for the cona nautical character. At the best the delineation of the coast-line, with such inaccurate and untrustworthy means as can alone be employed, can be but approximately correct, and only the positions of the most remarkable features, as well as the variation in the depth of the water, can be deemed really accurate.

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* It must be remembered, in using the artificial horizon, that the angle taken is double the true angle of elevation of the sun above the horizon, owing to the refraction of the mercury in the vessel, and that hence half the angle measured by the sextant will give the true elevation.

* The "lunar distance" is that between the moon and sun, or any fixed star or planet lying nearly in its path. When this is determined, the longitude can be found by calculation

Even less complete nautical surveys are undertaken occasionally, as, for example, the examination of a coast or harbour by a hostile fleet of vessels, where the distances are determined by the intervals between the ships, or the measurement between any two observed points or times in the ship's course, by means of the log, which gives the rate at which the vessel has travelled, and the chronometer, which indicates the number of hours taken in traversing that distance.

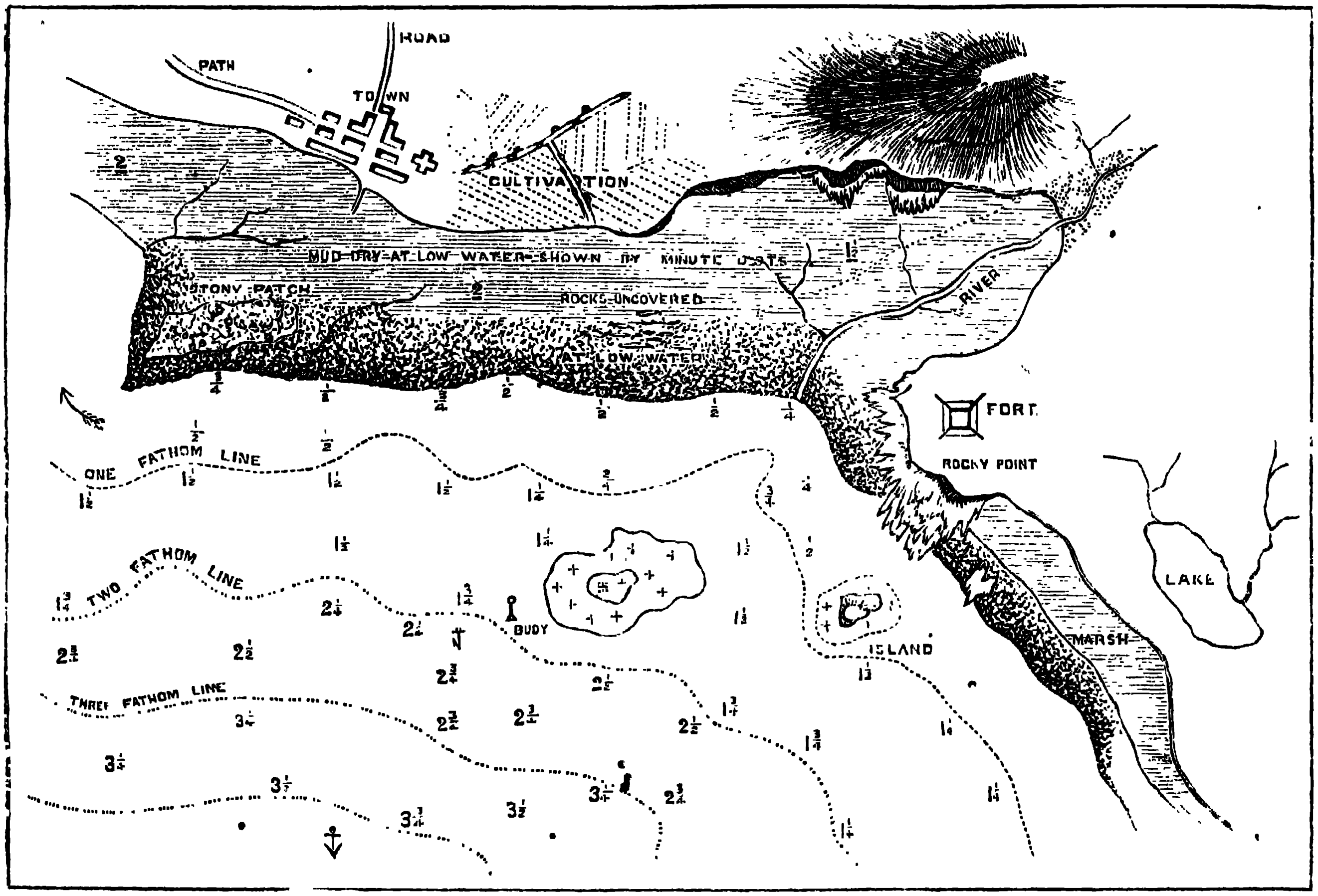

Fig. 9.—DIAGRAM SHOWING THE METHOD OF DELINEATING CHARTS.

The information afforded by a chart is first the general outline of the coast, with the positions of the prominent natural features inland, which serve, so to speak, as landmarks; and secondly, the variations in the depths of water, and the nature of the beaches or the sea-bottom. The latter is indicated by abbreviations of the actual name, as—

b,	blue.	*h,*	hard.	*s,*	sand.
bk,	black.	*m,*	mud.	*sf,*	soft.
brk,	broken.	*oz,*	ooze.	*sh,*	shells.
c,	coarse.	*oy,*	oysters.	*sm,*	small.
ch,	chalk.	*p,*	pale.	*sp,*	speckled.
cl,	clay.	*r,*	rocky.	*st,*	stones.
g,	gravel.	*rd,*	red.	*w,*	white.
gn,	green.	*rot,*	rotten.	*wd,*	weeds.

The other conventionalities used in the description of charts are shown as follows:—

Current

→ **Flood tide (direction of)**

→ **Ebb tide (do.)**

Kn. Knots or nautical miles

⚓ **Anchorage for large vessels**......... **Inside this line less than one fathom**

⚓ **Do. for small vessels** .. .. .. **Inside this line less than two fathoms**

⚓ **Do. for coasters** ... ... **Inside this line less than three fathoms**

H.W. High water . —. —. —. **Inside this line less than four fathoms**

L. W. Low water .. — .. — .. — .. **Inside this line less than five fathoms**

At low

+ **Rock with one fathom of water.**

✣ **Rock nearly awash.**

▨ **Sand that dries, with depth of water at high water.**

▨ **Mud that dries, with depth of water at high water.**

▨ Sandy beach

▨ Gravelly beach

▨ Stony beach

F. I. R. Near a lighthouse is fixed, intermittent, or revolving light

B. C. R. W. Near a buoy is black, chequered, red, or white.

No bottom at this depth.

fm. fathoms.

ft. feet.

spr. springs.

np. neap-tides.

The north point is marked in several places on the chart, with the variations of the compass. The value of the lines marking the number of fathoms is especially great in certain cases, as, for instance, in the English Channel. So carefully are they shown in charts of this portion of the sea, that navigators, even if they cannot fix their position by observation, owing to atmospheric disturbance, imperfect instruments, or other causes, can ascertain when they are entering it by sounding; and as the lines of equal soundings are definitely marked from coast to coast, they can approximately determine their place on the chart by knowing between which lines they are then passing.

SHIP-BUILDING.—XV.

BY W. H. WHITE,

Fellow of the Royal School of Naval Architecture, and Member of the Institution of Naval Architects.

METHODS OF SHEATHING IRON SHIPS.

PROPOSALS were made many years ago to cover the bottoms of iron ships with wood planking, and to nail upon that foundation copper or other metal sheathing in order to prevent fouling and the consequent loss of speed. The plan was not, however, used until recently, the first example of a sheathed iron ship being found, we believe, in the swift ocean-cruiser, *Inconstant*, designed for the Royal Navy about five years ago. In this case it was desired to unite very high speed with a very powerful armament, and with the power of keeping the sea for long periods without loss of speed. To reach the high speed, very powerful engines and a very finely-formed ship were required, both of which features tended to produce extremely severe strains that could only be borne without injury by an iron hull. On the other hand, to secure a bottom that should continue clean for long periods, it seemed desirable to use copper sheathing; consequently the experiment was tried, and so far the results have been satisfactory. Several other vessels, including two iron-clads, have been since constructed for the navy on similar plans, but we are not aware that any iron merchant ships have yet been sheathed with copper, the expense of such a mode of construction having probably prevented its adoption. Zinc sheathing has been tried in a few cases both in the Royal Navy and in the mercantile marine, and is preferred to copper by some ship-builders for reasons which will appear hereafter.

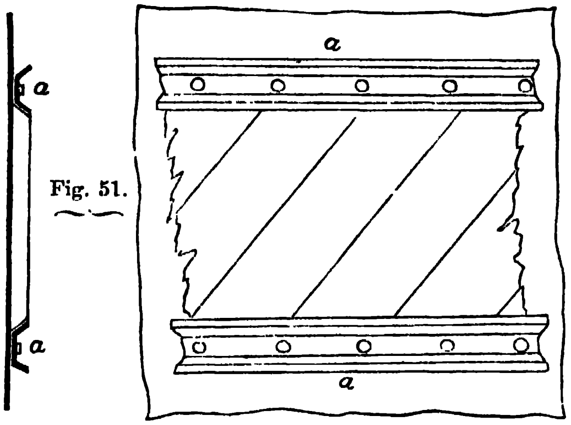
Fig. 51.

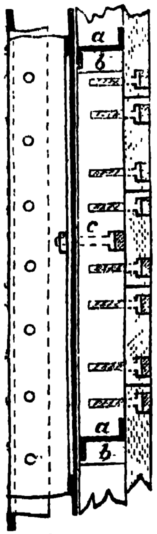
Fig. 48.

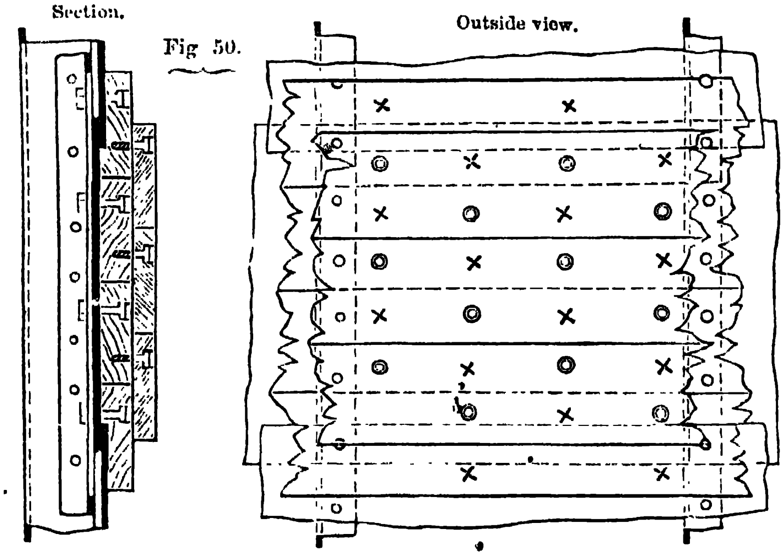
Fig. 50.

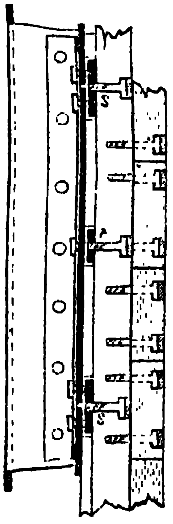
Fig. 49.

Refs. to Fig. 50.—⊙ Butts of outer planking; × Butts of inner planking; o Riveting of plating to frames.

If a piece of copper and a piece of iron are immersed in salt water, and metallic contact is made between them in a manner resembling that made between the two plates of a galvanic battery, galvanic action will be set up and the iron will waste. Hence it is necessary to use great precautions when iron ships are sheathed with copper, in order to prevent galvanic action and the consequent deterioration of the iron hull. Allusion has already been made to the similar caution required in the construction of composite ships, so that we need not dwell upon the matter now, simply stating that direct metallic contact, as well as indirect metallic connection, between the copper sheathing and the iron hull should be avoided as much as possible, and every means taken to make the wood planking and its fastenings sound and tight, in order that the skin plating may be kept dry. These are two most important conditions which ought never to be lost sight of in building vessels of this class.

Without further preface we will proceed to notice two or three plans for sheathing iron ships with copper, taking first one proposed by Mr. Grantham many years ago. The planking is wrought in two thicknesses (see Fig. 48), the inner thickness being fitted directly upon the skin-plating, and the outer thickness being fastened to the inner by copper or metal screw-bolts which do not pass entirely through the inner planks. The inner thickness is secured without using many (if any) bolts; a fact to which Mr. Grantham attributes much importance. Outside the skin-plating Z-shaped iron frames (*a*, *a*) are worked longitudinally at frequent intervals; the inner planks are worked in short lengths between these frames, and wedges (*b*, *b*) are driven in over the ends to secure the planks. This wedging arrangement has been much objected to by many practical ship-builders, who consider it to afford an insufficient attachment for planks to which all the outer planking has to be secured; and there seems much force in the objection. It is only right, however, to add that Mr. Grantham provides for the use of a limited number of bolts in some cases, these being placed mid-way between the external frames (like *c* in the figure), and secured by nuts and screws to the skin-plating. Where the main framing is transverse (as in Fig. 48), Mr. Grantham proposes to place the external frames longitudinally; but where the main frames are longitudinal, he would place the outside frames transversely. The principle is the same in both cases, and the whole arrangement for securing the inner layer of planking is based upon the belief that iron bolt-fastening should be avoided as much as possible, because of the probably rapid deterioration of such bolts if the planking became saturated, and galvanic action should be set up between them and the copper sheathing.

To some extent this view is doubtless correct, as experience with composite ships—having their planking in one thickness and fastened with iron bolts—proves. In such cases the large area of the copper sheathing has its action concentrated upon the comparatively small areas of the bolt-heads or shanks, and as a consequence their deterioration is often rapid. But the case is widely different when two thicknesses of planking are used and carefully fastened in the manner explained in page 277;

the iron bolts of the inner thickness then being comparatively distant from the copper sheathing, and not nearly so likely to suffer by galvanic action or other causes. This distinction between the use of one and two thicknesses of planking Mr. Grantham does not appear to recognise sufficiently in his arguments against bolt-fastenings, nor does he note the much greater strength to resist *working* in the sheathed ship. On his plan, too, the planking cannot be regarded as adding much, if anything, to the strength of the ship, because of its comparatively slight attachment to the hull. Of course, the iron hull in itself can be easily made so strong as to require no such assistance; but on the other hand, by arranging and fastening the planking differently, it may be made to help the hull proper considerably, while forming an equally efficient foundation for the copper sheathing, as will be shown almost immediately. It should be added that Mr. Grantham also proposed to use brass stems and stern-posts in sheathed ships, a plan which has been frequently conformed to, when other modes of securing the planking have been followed.

Fig. 49 shows in section the plan of sheathing first used in the Government service. The skin-plating is worked directly upon the frames, no liners being required, and the flush edge-joints are secured by external strips (*s*, *s*). These are made much thicker than the plating, in order to permit the ends of the iron bolts, forming the principal fastenings of the inner planking, to be screwed *into*, but not *through* them. Midway between the edge-strips other thick strips (*t*) are worked, in order to receive the screwed ends of additional fastenings; and the spaces between the strips are filled up with thin planks secured by marine glue, so as to form a flush surface, and avoid any necessity for scoring the inner layer of planking. This is worked transversely, the lengths of the planks extending from the keel towards the gunwale, and the butts being screw-bolted to strips fitted for the purpose. By these arrangements the inner planks are strongly secured to the hull, and yet the bolts leave the skin-plating itself unpierced, so that in case of an accident which stripped off the planking the skin would still remain water-tight. The outside planks are worked longitudinally, and secured by metal screw-bolts kept clear of the iron fastenings, and passing about two-thirds through the inner planks.

This plan is therefore, at least, as efficient as Mr. Grantham's in preventing metallic connection between the copper sheathing and the iron hull; and it makes a stronger and more intimate connection between the hull and the planking. It involves, however, the necessity for great care and considerable expense in order to secure thoroughly good workmanship in connection with the fastenings of the inside planking. For example, in drilling the holes in the strips caution is needed to prevent them from passing *through* the strips, and no less care is required to ensure exactitude in boring the bolt-holes in the planks so that the bolts may be properly hove up. For these and other reasons the simpler plan illustrated by Fig. 50 has been used in the later sheathed ships of the Royal Navy.

The plating is here worked on the common in-and-out plan. Both thicknesses of planking are worked longitudinally, the edges of strakes being brought upon the centre lines of strakes overlying or underlying them. The inner thickness is fastened by iron bolts screwed through holes tapped in the plating, and farther secured by nuts hove up inside the iron skin. Consequently damage to the bottom, even if it were to strip off the planking, would not be likely to cause a leak; because the screwed ends of the bolts would most probably remain in and fill the holes in the plating. And, in addition, if the nuts were broken off or removed by any mischance, the bolts would still have a hold on the plating.

The outer thickness is fastened in the usual manner by metal screw-bolts passing partially through the inner planks, and a reference to the outside view in Fig. 50 will show how these bolts are kept clear of the iron fastenings. A merely casual glance at the arrangement may lead to the opinion that this method of securing the inner layer of planking unduly weakens the skin-plating, and that it is consequently inferior in this respect to the preceding plans. But on a closer examination it will be remarked that the iron bolts are spaced further apart, on any transverse section of the plating, than the rivets are which attach the plating to the frames; so that the unavoidably weakened sections in wake of the latter still continue to be the places where fracture is most likely to take place, and no real loss of strength results from drilling the holes for the bolts. Moreover, it will be obvious that the two layers of wood planking form a skin possessing in itself considerable strength, and so efficiently connected to the iron hull as to be capable of lending it aid to a greater extent than can the planking on either of the other plans. Much has yet to be learnt respecting the limits within which wood and iron so combined may be considered to act jointly; but there is reason to believe that under such strains as may be considered of ordinary occurrence, the wood skin of a ship sheathed as in Fig. 50 would lend valuable aid to the iron plating; and on the other hand, the plating would probably do much to prevent that working in the wake of the fastenings which is likely to take place in the skin-planking of wood and composite ships. The plating of sheathed ships is usually somewhat thinner than that of unsheathed iron ships of equal size; but the difference in thickness is not great, and the reduction actually made is regulated rather by consideration of the fact that the planking has to be fastened to the plates, than by a regard to structural strength.

At the outset it was stated that the prime object of the wood planking was the prevention of metallic contact or connection between the copper and the iron hull; but one indirect advantage gained by the thick coating of wood is the greater strength of the bottom to resist penetration by blows which would break through unsheathed plating. Double bottoms are consequently not so necessary in sheathed ships as in ordinary iron vessels, and they have not been constructed in most cases. However the planking may be arranged, care is required in caulking both thicknesses, making the bolts water-tight, and coating the faying surfaces with some water-tight material, such as marine glue; in short, no means should be left untried to prevent the iron plates and bolts from becoming damp, and wasting by rusting or galvanic action.

There have been many other proposals for sheathing iron ships with copper, to which reference might be made did space permit. One only can be mentioned, which was put forward by Mr. McLaine, and was most novel in conception. His plan was to build the iron ship with frames *outside* the skin instead of inside; then to bolt wood timbers to the frame angle-irons, and upon these timbers to fasten wood planking in combination with a wood keel, stem and stern-post. In fact, his method may be shortly summed up as a combination of the timbers, planking, keel, etc., of a wood ship, with the skin, decks, bulkheads, etc., of an iron ship, the connection between the two being made by the means described. Some high authorities expressed favourable opinions respecting this plan, but it has not, we believe, ever been practically applied, and it would certainly lead to both costly and heavy ships.

Attention must next be turned to zinc sheathing for iron ships, which has been strongly advocated by many persons in preference to copper. When zinc and iron are immersed in salt water, and the circuit completed by metallic connection between the two, galvanic action is set up, the zinc wasting while the iron remains unoxidised. Consequently no injury to the hull need be anticipated from sheathing an iron ship with zinc; and in this respect such sheathing is doubtless superior to copper. It is also much cheaper—about one-third the price of copper; but the question of its anti-fouling qualities as compared with copper is not thoroughly settled, and this is a most important one. Copper when immersed in sea-water becomes oxidised on the surface, and this oxide being soluble is slowly and gradually washed off, so preventing the attachment of marine plants and animals that would otherwise cause foulness of bottom. This process, termed "exfoliation," is often so very gradual that the copper sheets last for very many years under water, and yet keep the bottom of the ship clean. Zinc, on the contrary, when used to sheath the bottoms of wood ships, does not exfoliate like copper, the oxide formed upon its surface not being readily soluble, and consequently it does not keep the bottoms so clean; still its cheapness leads to its frequent use on wood merchant ships, and under these circumstances it lasts for a long time. To render zinc sheathing more efficient against fouling, it is necessary to establish galvanic action by bringing it into contact or connection with iron or copper bolts in wood ships; or in the case of sheathed ships allowing it to have some contact with the iron plating or other pieces of the hull. Its oxidation then becomes much more rapid, and its anti-fouling properties are increased; but on the other hand it wastes much more rapidly than before, and requires to be sooner renewed. The larger the surface of zinc and iron in contact the more rapid is the waste of the zinc; and so far the chief difficulties attendant upon the use of zinc sheathing for iron ships have been caused by a want of certainty in our knowledge respecting the regulation of the amount of contact between the two metals. This regulation should be such as to give an amount of contact just sufficient to keep the surface of the zinc clean, so that it should not waste too rapidly (because the zinc might then require to be renewed so frequently as to more than do away with its advantage in first cost as compared with copper); and it should provide the contact in such a fashion as to secure a uniform wasting over the whole surface of the zinc. Experience may help us to decide how these desiderata may be obtained; but at present they do not seem to have been secured, and consequently copper sheathing is preferred.

Passing from these general considerations, we will notice a few of the methods proposed for sheathing iron ships with zinc. One of the simplest plans tried consisted in securing sheets of zinc outside the plating by means of light iron rods riveted around the edges of the sheets, and a few small studs placed near the centres. This appears, however, to have made the surfaces of contact between the iron and the zinc much too great, and as a consequence the latter wasted rapidly, leaving the iron plates exposed.

Mr. Daft's plan for zinc-sheathing has attracted much attention, and has, we believe, been experimented upon on a small scale with some success, but has not been practically applied. He proposes to arrange the plating very similarly to that shown in section *a*, Fig. 34, page 305; but instead of bringing the edges of adjacent strakes close together, to leave narrow spaces between them, and to treat the butts similarly. Into these spaces strips of wood would be driven, and to these strips the edges of the zinc sheets would be nailed. The sheets would consequently require to be of the same size as the plates, and their centres would be secured by a few small studs. Felt or some other material of a similar kind is proposed for use as a bedding to the sheets, in order to reduce the amount of contact between the zinc and the iron. Various objections have been raised to the structural arrangements which this plan would render necessary —the edge-strips, numerous liners, and broader butt-straps that would be needed; the want of proper fitting of iron to iron at the butt-joints; the greater labour of plating and caulking, etc. These objections, doubtless, have some force, and probably have contributed to prevent any ship being thus built and sheathed.

In another plan, proposed by Mr. Bell, the plating would be worked as usual, except that strips of plating would be fitted between the laps of the raised and sunken strakes in order to increase the depth of the recesses over the latter. Thin wood planking, arranged diagonally, would be fitted into the recesses, and secured to the sunken strakes by a few bolts. To these planks the zinc sheathing would be nailed, and would consequently, unless some material were interposed, be in direct contact with all the outer strakes of plating; but it is proposed to regulate the amount of contact by trial. An alternative proposition by the same gentleman is to plate the ship as shown in Fig. 49, and to fit the wood planks between thick edge-strips similar to *s*, *s*. The zinc sheets would then touch the edge-strips only, and their surface of contact would be much less than on the other plan. Iron nails in the zinc sheathing are suggested as a simple means of increasing the metallic connection if that should prove desirable. So far as we know, neither of these plans have been practically tested, and it is unnecessary to criticise them.

The last plan we shall describe is now under trial in one of the iron-clad ships of the navy. It was proposed by the late Mr. Lungley, and is illustrated by Fig. 51. The outside plating is worked on the usual in-and-out plan; and to secure the wood planking to which the zinc sheets are nailed, channel-irons (*a*, *a*) are riveted to the iron skin. The planking is fitted diagonally between these channel-irons, and the zinc sheets consequently come into direct contact with iron only at the edges of the channels. Metallic connection is, however, made by the nails in the sheathing, these passing through the wood and touching the iron plates; and the amount of the action set up on the zinc may obviously be increased by using iron or metal nails instead of zinc. The experiment has not yet extended over a period sufficiently long to lead to conclusive results; but it will probably do much to advance our knowledge of the conditions essential to the successful use of zinc sheathing. Experience of a more decided character is required before ship-builders will be able to employ zinc with the certainty of success; but should this be obtained, the cheaper metal will, no doubt, be extensively used instead of copper.

SEATS OF INDUSTRY.—XXIX.

BRISTOL.

BY WILLIAM WATT WEBSTER.

ONE of the most ancient cities and centres of trade and manufactures in the United Kingdom, and for a long period second only to the metropolis in commercial and social importance, Bristol, though outstripped by younger rivals, still takes high rank among the towns of Great Britain, and the story of its rise, pre-eminence, and relative decline, forms a singularly interesting and instructive chapter in the history of English commerce. We say *relative* decline, because Bristol has in reality suffered no positive decadence, although it has not recently progressed at the same rate as some other more fortunately-situated towns in this country. There does not appear to have been any very marked falling off either in the enterprise or in the intelligence of the inhabitants of this famous city in more modern times; it is rather the great opportunity that has been lacking to them. The current of commercial prosperity would seem to have changed its course, and left Bristol in an eddy of the stream. An examination of the chief causes that have contributed to raise Liverpool, for instance, into the position it now occupies, and to throw Bristol into comparative obscurity, will show that the latter could not possibly have taken advantage of them. Indeed, the later trading history of Bristol, considered in connection with that of English towns which have increased more rapidly in population and wealth, forcibly illustrates the effect that the introduction of new industries exercises in determining the relative importance of commercial and manufacturing centres. It is to its proximity to the great manufacturing districts of the north of England, as we have seen in a previous paper, that Liverpool is principally indebted for its extraordinary development and growth. Bristol had not in its neighbourhood the resources necessary for the carrying on of such extensive manufacturing enterprises as constitute the foundation of the prosperity of Liverpool.

Nothing is known of the origin of Bristol, but under the names *Caer Brito* and *Caer Oder*—the latter signifying the "town of the chasm," and denoting its position by the "rifted rock" —it is supposed that it can be traced to a period as far back as the time of the ancient Britons. The Romans fortified the place, and after their departure from the island, it fell back into possession of the native princes, and formed part of the territory of the Cornish Britons. It is included in the lists of fortified and eminent towns drawn up by Gildas in the fifth, and by Nennius in the seventh century; and in 584 it was captured by Crida, King of the West Saxons. Its present name is generally believed to be a corruption of the Saxon compound *Brice-stow* or *Bright-stowe*, which means "a pleasant place;" but numerous other explanations of it are given. It would appear to have been visited by Jordan, one of the monks who came to Britain with Augustin; and certain antiquarians contend that Bristol was the scene of the famous conference between the Roman missionary and the British bishops in 603. The first unequivocal mention of the place in history, however, is in the reign of Athelstan, in the beginning of the tenth century. Next to London Bristol was the principal port in the country in Anglo-Saxon times. In a memoir of Wulfstan, the Bishop of Worcester at the time of the Norman Conquest, the following passage occurs:—"There is a seaport town called Bristol, opposite to Ireland, to which its inhabitants make frequent voyages of trade. Wulfstan cured the people of this town of a most odious custom which they derived from their ancestors, of buying men and women in all parts of England, and exporting them to Ireland for the sake of gain. You might have seen, with sorrow, long ranks of youths and maidens of the greatest beauty tied together with ropes and daily exposed for sale; nor were these men ashamed—oh, horrid wickedness!—to give up their nearest relations, even their own children to slavery." In the "Domesday Survey" the town is called *Bristow*, and it was then a royal borough, its governor being a noted merchant, said to be of Danish origin, named Hardinge, whose son, Robert Fitzhardinge, the first Lord of Berkeley, succeeded to the government. In the reign of William Rufus the fortifications of the town were strengthened. Bristol was captured in the reign of Stephen by Robert Earl of Gloucester, the illegitimate son of Henry I., and held by him for his sister Maud, during which time the castle was rebuilt and enlarged, and made one of the strongest in the country, its walls being about twenty-five feet thick. In this castle Henry II. was partially educated, and Stephen was for a short time a prisoner. About the year 1140, a monastery of the Augustin order was established at Bristol by Robert Fitzhardinge, which was made an abbey by Henry II., and continued to flourish till the dissolution of the monasteries by Henry VIII. in 1540, at which time its revenues amounted to £767. Fitzhardinge also founded the priory of St. James, the church of which was afterwards made parochial, and a nunnery was built by Eva his widow. William of Malmesbury, who died in 1148, speaks of Bristol as "a very celebrated town in which there was a port, the resort of ships coming from Ireland, Norway, and other countries beyond sea." Henry II. granted the town a charter in 1165, increasing its commercial privileges, and in 1175 he took possession of the castle. Early in the thirteenth century a new channel was cut for the river, and a new quay, adapted to the extensive and growing trade of the port, was constructed. For its time this was a remarkable engineering work. In 1285 Edward I. assembled a Parliament at Bristol. A few years later a Bristol merchant, named Walter Hobbe, seized a ship and cargo in the port, belonging to a merchant from Holland, but after a long course of litigation he was forced to surrender both, and pay £65 for the loss he had caused the Dutchman to sustain. The old chronicler who relates this incident remarks that it would be "a thing of great danger at those times, and such as might occasion a war, to suffer alien merchants, particularly those of Holland and Brabant, to depart without having justice done them," which is surely a sensible comment so far as it goes. Bristol was the seat of a rebellion in the reign of Edward II., and held out for four years against the royal forces. About this date extensive manufactures of soap, cloth, and glass were carried on in the city; and in the reign of Edward III. many of the weavers who had come over to England from Flanders settled in Bristol, and materially contributed to its prosperity by making it the chief centre of the woollen manufactures of the kingdom. Blankets were first made by, and derive their name from a Flemish manufacturer named Thomas Blanket, who, with his two brothers, were among the earliest promoters of cloth-making in Bristol. As a matter of course, Mr. Blanket's innovations were opposed by the civic authorities, who in 1340 fined him heavily "for having caused various machines for weaving and making woollen cloths to be set up in his house, and for having hired weavers and other workmen for this purpose;" but the fine was afterwards remitted by a special injunction from Edward III. After a short time the inhabitants of Bristol perceived that the inventor of the blanket was a public benefactor, and he was made bailiff of the city. He and his two elder brothers carried on an extensive home and foreign trade for many years, and from their time till the discovery of America cloth was the principal article of commerce in Bristol. It was made one of the staple towns for wool by Edward III. in 1353, and twenty years later this monarch constituted the city a county in itself and declared it free from all feudal obligations. As an evidence of the wealth of Bristol at this period, it may be mentioned that it furnished 22 ships and 608 seamen, a force as large as that contributed by London, to the fleet sent to besiege Calais shortly after the battle of Crecy in 1346. Bristol was besieged and taken in 1399 by Henry Duke of Lancaster, who in the same year ascended the throne as Henry IV. In a charter granted by this monarch in the following year, acknowledgment is made of "the many and notable services which very many merchants, burgesses of our town of Bristol, have done for us and our famous progenitors in many ways with their ships and voyages, at their own charges and expense."

During the second half of the fourteenth century there flourished at Bristol a famous merchant and manufacturer, William Canynge or Canning, the founder of a family to which the city was greatly indebted. He was twice bailiff, six times mayor, and three times returned as representative of Bristol in Parliament. In 1396 he died, leaving a large fortune acquired principally by foreign trade, the greater part of which was devoted to charitable objects. His son John was also a merchant of repute, and served the town in the capacities of bailiff, sheriff, member of Parliament and mayor, and at his death, in 1405, he left a third of his goods to his wife, a third to his children, and a third to the poor. Thomas Canynge, the eldest of John's descendants, settled in London, and rose to the dignity of member of Parliament for the City in 1451, and mayor in 1456. When he was sheriff of the metropolis in 1450, he took part in the suppression of Jack Cade's rebellion, as we learn from a petition addressed to Henry VI. by himself and his fellow-sheriff, asking remuneration for the expense, trouble, and danger they had incurred in "drawing the body of the great traitor upon a hurdle by the streets of the City of London," and in distributing the head and quarters as directed; "the which commandments," says the petition, "were duly executed to their great charges and costs, and especially for the carriage of the quarters aforesaid, for and because that hardly any persons durst or would take upon them the carriage of the said head and quarters for doubt of their lives." Thomas Canynge was considered a man of great energy and high character, but his brother William, known as William Canynge the younger, who was born in 1399 or 1400, greatly excelled him and all his family, indeed, in wealth and fame. This was the greatest of Bristol's old merchant princes. By the middle of the fifteenth century there were about 66 ships and about as many boats belonging to the port, and its merchants carried on an extensive trade not only with Ireland and Wales, but also with France, Russia, Prussia, and the Levant. William Canynge the younger, during the eight years preceding 1460, employed on an average 800 seamen in the navigation of his ten vessels, which had an aggregate burden of 2,930 tons. He gave occupation besides to about 100 artisans. Several of Canynge's ships were among the largest of their day; the *Mary and John* being 900 tons, the *Mary Redcliffe* 500 tons, and the *Mary Canynge* 400 tons burden, and the three cost him in all 4,000 marks, or considerably more than £25,000 in our money. By a treaty concluded between Henry VI. and the King of Denmark, the merchants of Bristol and several other towns were forbidden to trade with the inhabitants of Iceland, Finland, and other districts subject to the Danish crown; but the Danish king made an exception of William Canynge, who was permitted, "in consideration of the great debt due to the said merchant from his subjects of Iceland and Finmark, to lade certain English ships with merchandise for those prohibited ports, and there to take fish and other goods in return." In 1449 Henry VI. sent letters of commendation to the Master-General of Prussia and the magistrates of Dantzic, inviting their favour towards certain English factors established within their jurisdictions, and especially towards William Canynge, "his beloved and eminent merchant of Bristol." Canynge, like his grandfather, passed through all the higher offices of his native city, and greatly distinguished himself. He was a staunch supporter of the Lancastrian cause, and at his own expense built "a stately vessel only for war," to protect the city against the Yorkists. In 1456 he entertained Margaret of Anjou when she visited Bristol for the purpose of quickening the interest of the western counties in the falling fortunes of her husband. Five years later, on the failure of the Lancastrian cause, Canynge had to welcome Edward IV. to the city, when that monarch came to ascertain how much money could be levied from the wealthy merchants of Bristol. Being the richest man in the town, and at the same time the most zealous supporter of the Lancastrian house, Canynge had to pay the king 3,000 marks, or about £20,000, "for the making of his peace," but he was also instrumental in securing certain important trading privileges for Bristol, in return for the money he and his townsmen delivered to his majesty. During his last mayoralty, Canynge formed the merchants of Bristol into a guild, for mutual protection in regulating the prices of various articles of trade and for mutual help in misfortune, which although repugnant to modern economical policy, exercised at that time and for a long period after a beneficial influence on the commerce of the city. He spent much of his wealth on the restoration of the ancient and noble church of St. Mary Redcliffe, and in 1467, his wife and children being all dead, "he gave up the world, and in all haste took orders upon him, and in the year following was made priest and sang his first mass at Our Lady of Redcliffe." It is said that Canynge was induced to take this step in consequence of a project of Edward IV. for finding him another wife, and exacting a large sum of money for his matrimonial agency fee. In Canynge's time there was a large number of great merchants in Bristol, including Robert Sturmy, who lived in lordly style and had extensive dealings with the Levant, and the brothers Jay, a family that was famous in two generations. In a work written towards the close of the fifteenth century, we read that in 1480 "a ship of John Jay the younger, of 800 tons, and another, began their voyage from King's Road to the island of Brazil, to the west of Ireland, ploughing their way through the sea." The ships did not discover the "island," although they sailed the sea for nine months; but was this a veritable voyage of discovery, or is there some mistake in the record?

There seems to be no good reason for doubting that John Jay at this early date sent out ships in quest of a new field for trade on the other side of the Atlantic. The Spanish ambassador at the English Court informed his sovereign in a dispatch dated 1498, that "for the last seven years the people of Bristol have sent out every year two, three, or four light ships in search of the island of Brazil and the seven cities;" and if we accept this statement as correct, it proves that the merchants of this town were searching for the New World at least two years before Columbus made his first voyage of discovery. But whether this be so or not, there is no room for doubting that a Bristol merchant of Venetian birth, named John Cabot, landed on the American continent before either Columbus or Americo Vespuccio. On the 5th of March John Cabot obtained from Henry VII., for himself and his three sons, Sebastian, Ludovico, and Sanzio, letters patent for the discovery of new lands, and in May of the following year he sailed out of Bristol with two vessels manned by a crew of three hundred men, which he had equipped with the help of his brother merchants. On the 24th of June he sighted land, which he supposed to be Cathay, "the territory of the Great Khan," but which turned out to be Labrador. In 1498 Sebastian Cabot left Bristol with a small fleet, and after searching for a north-western passage to India, explored the North American coast as far as Chesapeake Bay. The Cabots made no profit out of these expeditions, but at a later period their townsmen established a trade with Newfoundland that largely contributed to the prosperity of Bristol. On the visit that he paid to Bristol in 1487, Henry VII. marked his sense of the wealth and luxury that prevailed in the city by imposing a fine on such of the citizens as possessed property to the value of £20, on the pretext that the ladies dressed in too gorgeous and costly robes. The kings of England in those times resorted to peculiar methods of raising money.

MUSEUMS: THEIR CONSTRUCTION, ARRANGEMENT, AND MANAGEMENT.

BY SAMUEL HIGHLEY, F.G.S.

IX.—NATIONAL MUSEUMS (*continued*).

FROM what has been stated in previous articles it will be seen that the severance of the natural history from the antiquarian and bibliothecal collections of the British Museum will afford ample space for the time being, in the Bloomsbury building, for the development of the collections illustrative of *human history*, which should include selected specimens from the Tower armouries, Meyrick collection (*if* secured to the nation?), Woolwich Arsenal, and Indian Museums. An extension of the National Gallery building would allow of the sculpture and pictorial art treasures being arranged in such manner as would best illustrate *Art*, and extend a sound knowledge of its principles among the people. *Practical Art* and *Economic Science* should find a place in their recognised home at the South Kensington Museum, in association with a teaching staff at the Science and Art Schools, while *Natural History* in its purely scientific aspects would find ample space for its full development according to modern ideas on the site now secured for the New Museum, to the south of the International Exhibition. Were the Economic Collections of the Kew Museum brought into association with the Museum of Practical Geology and the Food Collections of South Kensington, the Botanic Gardens at Kew would afford the collection of living plants desired by the memorialists of 1858; and it might be a question whether Government should not assist the Zoological Society with an annual grant, on the condition that the living animals should be grouped in more systematic order, and that that powerful aid to a knowledge of the habits of the invertebrata, the aquarium, should be re-organised, according to the latest experience, as developed at the Crystal Palace by that enthusiastic practical naturalist, Mr. Alford Lloyd, for in its present condition the aquarium house is a disgrace to the gardens of the Zoological Society.

I shall devote the remainder of this article on our science, art, and antiquarian collections, to a description of the probable arrangement and management of the new "National Museum of Natural History," under the directorship of Professor Owen, as a type of what might serve as a model for other countries. A National Museum of Natural History should comprise two separate buildings. One should be devoted to an elementary series forming an epitome of the leading principles of natural history, so constructed that it would provide for the general public being admitted not only during the hours of the day, but in the evening, for the benefit of the working classes and others engaged in business during the day. The other building would be devoted to the scientific or classified collections, and should be constructed so as to provide for the convenience of the general public, and the special requirements of students and scientific naturalists between the hours of ten and four. The two buildings should be sufficiently isolated, to provide against the destruction of the Scientific Museum, should a fire by any accident arise in the Elementary Museum. It would therefore be better to place the Elementary Museum at one end, rather than in the middle of the buildings, as proposed in Professor Owen's plans of 1859 and 1862; for though such a disposition may appear more symmetrical from an architectural aspect, in the event of a fire occurring in a central structure—the Elementary Museum being the only part where artificial illumination should be admissible—the destructive element would literally be provided with two strings to its bow, and the difficulty of confining a conflagration to its narrowest limits would be materially increased. The smaller building might be called the "Index Museum," or as Professor Owen considers a circular structure would be the most convenient form, as it "admits of the most economic and effective supervision" for an introductory series, the "Rotunda of Elementary Natural History" would provide a designation that would perfectly define its aims.

Estimate of Space.—On the first announcement of Professor Owen's scheme for a new Museum for the British Natural History Collections, much misconception prevailed, and even prevails to the present day, as to his real ideas on the subject, which may have arisen from misstatements of his views, similar to that made by Mr. Gregory when he announced in Parliament that a gallery of 850 feet in length was proposed to be devoted to whales. The truth was, that 850 feet was specified in the plan of 1859 as the entire length of the "Mammalian Gallery," but the veriest schoolboy ought to know that the single *order* Cetacea does not constitute the entire *class* Mammalia. Yet this gross misrepresentation led to Lord Palmerston's protest against the admission of whales into our National Museum, and making the quaint suggestion for the excision of the cetaceans out of the scheme of Nature. Now that science is being taught in our great public schools, such as Eton, Rugby, Marlborough, Winchester, and the masters are desirous of teaching it still more extensively on the soundest basis that our scientific educationists can indicate and practical experience establish, we may hope in future days to be saved from such lamentable displays of ignorance on the most elementary conceptions of the aims of the naturalist, under the roof that covers "the collective wisdom" of our country, by those who would patronisingly pat an Owen or a Huxley on the back as "men fond of beetles." Professor Owen's scheme has been regarded as "extravagant" both as to idea and cost, if carried into execution; but when the keepers of the several departments came to make estimates of space for their individual requirements, it was found that their demands exceeded those originally made by Professor Owen in 1859.

It will be found that Professor Owen always has spoken, in his printed reports and works as to the necessity of the curator being guided by "the principle of selection" as to what specimens were best suited for public display, though he enforces the necessity for the skins and skeletons of all large animals being arranged in the public galleries, as unwieldy specimens could thus be more conveniently examined than if kept packed in boxes, etc., in the store-rooms or studies; for though boxes drawers, etc., may be a convenient and practical arrangement for specimens of birds, bats, and "such small deer," the system does not hold good for bulky or pachydermatous animals, as common sense indicates. On referring to the tabular form given at page 320, under the column headed "Estimate of New Museum," it will be seen, that according to the returns of the keepers of the several departments, based on the data laid down by Professor Owen, previously defined, a gallery length of at least 7,400 feet by an average width of 50 feet, together with an area of about 300 square feet for an Index Museum, is essential for the proper display of any National Collection of Natural History; or an entire area of 322,100 square feet, equal to about seven and a quarter acres, and add, as Professor Owen says in his Report of 1862, "for architectural requirements, for light, access, galleries, halls, symmetry, and ornament,* say three acres, and the whole would call for a building of two storeys upon about five and a-half acres of ground."† This, says Professor Owen, in his edition of 1862,‡ "is scarcely one-sixth the size of the Exhibition Building of 1862, for the arrangement and display of the samples of industrial products of the present generation." "One mile of galleries stored with examples of creative skill may leave the traverser somewhat wearied, but thousands gladly court the greater fatigue of six miles of gallery stored with the works of industry of all nations."

Professor Huxley, in his examination before the British Museum Parliamentary Committee,§ stated that he considered six such rooms as the Ornithological Gallery in the British Museum (which is 300 feet long by 45 feet wide), "with appropriate offices," would afford ample space not only for the existing zoological collections, but also for future additions for fifty years to come. This would only amount to a gallery length of 1,800 feet, or 2,600 feet less in length than estimated by the officers of the British Museum. By reduplication at the ends of the rooms, the absolute length of wall-cases (having a depth of 3 feet) in the Ornithological Gallery equals 900 feet, and the floor-space allows of two rows of table-cases 10 feet long by 4 feet 7 inches wide, with an allowance of 3 feet space between the cases. Such a Zoological Museum (*without the appropriate offices!*) would not cover more than 2 acres of ground. As an illustration of the ratio of specimens required for public exhibition on the typical system, Professor Huxley considered that 1,500 species would be a very large allowance for the needful illustration of ornithology as to form, colour, and structure, and that the male, female, and young, different ages or varieties of the same animal need only be exhibited, where any law, fact, or considerable truth could be illustrated. "Every *fact* of variation should be properly illustrated, but every variety, say of the class of birds, should not be exhibited in the public galleries." The estimate of that practical curator, Professor Agassiz, for the Museum of Comparative Zoology of the State of Massachusetts, not only confirms, but exceeds that made by Professor Owen, as for the illustration of zoology solely, he required and secured "an oblong square of about five acres," on which galleries having a collective length of 6,000 feet by 50 feet wide have been built. We may therefore assume that the estimate for space for the New Museum of General Natural History is not founded on extravagant ideas or an unsound basis, when two such eminent naturalists as Professors Owen and Agassiz, who have devoted the greater part of their lives to the details of Museum arrangements, independently arrive at such a close approximation to the same conclusion; and I believe another practical curator, Professor Flower, the Conservator of the Museum of the Royal College of Surgeons, also considers the space specified in Professor Owen's Report essential for the proper elaboration of the National Museum of a great, wealthy, and intellectual country. Now that the desired ten acres of ground has been acquired, Mr. Waterhouse's plans approved, and £35,000 voted for the erection of the Museum, it is to be hoped the building will be proceeded with without further delay, for it is to be regretted the debate of 1860 has had the effect of postponing the decision of Government on such an important question for a period of twelve years.

MINING AND QUARRYING.—XXV.

BY GEORGE GLADSTONE, F.C.S.

LEAD (*continued*).

ASSAYING—SMELTING—THEORY—SMELTING IN REVERBERATORY FURNACES AT ONE OPERATION—CALCINERS—FLOWING FURNACES—THE ORE HEARTH—SLAG HEARTH.

In North Wales a flat iron bason with a lip is used, and if the ores are rich they are reduced in this without the addition of any flux whatever, but if poor a little carbonate of soda is added. The bason is covered with a close-fitting iron lid, and then put into an open forge for five minutes. By that time the greater portion of the metal is separated, and a scum, or slurry (as it is there called), is found to cover the surface. This is pushed to the back of the bason, and as soon as the slurry has sufficiently solidified the lead is poured out into a mould. The slag is then re-heated for about an equal time, to free any metal that may have become mechanically suspended by it, and this is then poured out as before. The sum of these two meltings will give with great exactness the quantity of metal in the ore.

If earthen crucibles are used, some small pieces of iron, or wrought-iron nails, are put into the crucible, care being taken that they reach to the bottom, or else some of the sulphide may escape decomposition. All the pieces of iron must be withdrawn before the contents of the crucible are allowed to cool, or they will become fixed in the lead.

Any silver that may be present in the ore, will be found in the button of lead weighed by the assayer, so that the result must not be understood to represent the per-centage of pure metal, but of the argentiferous lead. In a small sample, such as 10 oz., which is a common quantity to be assayed at a time, the silver will only be represented by a fractional quantity, as 0·1 per cent. of silver is equal to a yield of 32⅔ ounces to the ton. The same remark will apply to the gold; but it scarcely ever happens that it amounts to an appreciable quantity, even in an assay balance of the most delicate construction. Sulphide of antimony, which is not an uncommon ingredient of lead ores, will in like manner affect the result of the assay. If copper is present, about one-third will probably find its way into the metal, the remainder being retained in the slag. Iron will not affect the assay at all, as the whole of it will pass into the slag. Zinc and arsenic, being both very volatile substances, will not interfere with the calculations of the assayer.

At many of the great lead mines, such as those of Mr. W. B. Beaumont, at Allenheads, the reduction-works are on the spot, and form part of the same establishment, so that the ores obtained from them do not come upon the market; but where the ores have to be sold to smelters, this is generally done by ticket, upon the same plan that tin and copper ores are sold in Cornwall and Swansea. The argentiferous ores, which term includes all those which contain sufficient silver to cover the cost of separation, are of course assayed for both metals, and fetch a corresponding price. Anything above from two to three ounces of silver to the ton will repay the cost of desilverisation.

The smelting of lead is a comparatively simple process theoretically, but it will be seen from the following descriptions that in practical operation there are a great many details which call for the exercise of ingenuity, and which also involve a very heavy outlay for plant.

The theory of the process consists in converting the ore, which is the sulphide of lead (PbS), into either the oxide (PbO) or the sulphate ($PbSO_4$); and then fusing either or both these with a quantity of the unchanged ore in certain proportions which will yield metallic lead (Pb) and sulphurous acid (SO_2).

The following formulæ will show what relative proportions will give the best result; that is, will liberate the whole of the lead in the ingredients. No other proportions will be found to fulfil this condition:—

2 of oxide to 1 of sulphide ($2PbO + PbS = 3Pb + SO_2$).
1 of sulphate to 1 of sulphide ($PbSO_4 + PbS = 2Pb + 2SO_2$).
1 of sulphate and 2 of oxide to 2 of sulphide ($PbSO_4 + 2PbO + 2PbS = 5Pb + 3SO_2$).

In practice, of course, exact results like these cannot be at-

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[*] In an article contributed to the *Gardener's Chronicle* (page 749, vol, for 1858) Dr. Hooker suggests the advantage of a grass-plot being laid round a Museum, as "it not only cools and moistens the impending atmosphere, but mechanically retains the dust swept off surrounding objects by surface currents."

[†] Parliamentary Papers, Vol. XXXII., 1864.

[‡] "On the Extent and Aims," etc., previously cited.

[§] See Parliamentary Papers, Vol. XVI., 1860.

tained: firstly, because none of the ingredients are perfectly pure; secondly, because there is always more or less reaction between them and the materials of which the furnace is composed; and thirdly, because lead is easily volatilised, and a considerable portion of the metal passes away in the fumes. Owing to these unavoidable sources of error, it is found that there is nearly always an excess of the oxide and sulphate, and, therefore, that the proportion of lead represented by the undecomposed portion of them is left unreduced.

Almost all the lead works in this country are conducted upon the principle of this double reaction; but there are different modes of carrying it out, which will have to be noticed separately. At many of the Continental establishments, especially where the ore consists largely of silicates, the lead is reduced by the direct action of metallic iron—an application on a large scale of the principle described above for the assay of lead ores.

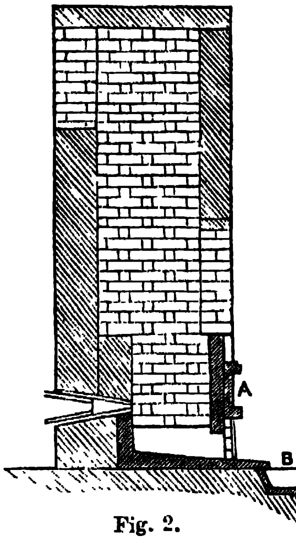

Fig. 2.

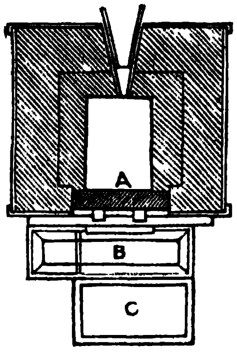

Fig. 3.

To return to the English practice. There are two kinds of furnaces used—the reverberatory and the blast furnace. The use of the latter, called the "ore hearth," is almost confined to the northern counties and to Scotland.

The reader will ere this be so familiar with the ordinary arrangements of the former that a lengthened description will be unnecessary. One reverberatory furnace may be made to yield the metallic lead from the dressed ore at a single operation; but in some works the calcining of the ore and the subsequent reduction of the metal are conducted separately in their respective furnaces.

The entire operation, according to the first plan, is accomplished in 4½ to 5 hours. The hearth of the furnace is made to slope down from each end and the back, to the centre of the front side, which part is connected by a pipe with a bason for the molten metal outside the furnace, similar to that used in the smelting of tin. The sole or hearth is made of old slag broken up, and heated sufficiently to enable it to be beaten down into a solid mass. The ore is supplied through a hopper in the roof, and there are usually three working doors on each side of the furnace through which the furnace-man and his attendant work the charge.

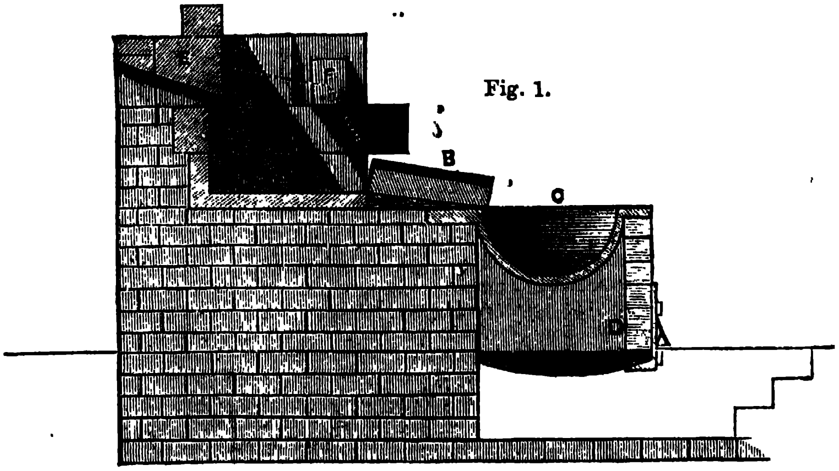

Fig. 1.

The temperature of the furnace is only moderate when the charge, say 20 cwt., of ore is introduced through the hopper. The assistant immediately spreads it evenly with his rake over the hearth. Then the furnace-man skims off the slags resulting from the previous charge, which overlie the lead in the bason outside, and throws them into the furnace by the working door furthest removed from the fire. The metal from these slags soon runs down and flows through the pipe into the bason. A second skimming takes place, and the slag is thrown into the furnace as before. While the assistant at the back is attending to the present charge, the furnace-man ladles the lead from the preceding one out of the bason and pours it into the pig-moulds. At the end of two hours, during which time the temperature of the furnace has always been kept at only a dull red heat, and a plentiful supply of air has been admitted by the working doors, the roasting or calcination of the ore is complete, and the second process, or smelting, begins. In this the fire is increased and the doors closed, so that in half an hour the furnace will be got up to a bright red heat, and the lead will be found flowing down towards the middle. The slags are then raked up to the ends and spread out, and some quicklime is thrown in upon the lead. The charge is then well worked by both the smelter and his assistant for about half an hour. The furnace is next allowed to cool down a little, after which the process just described is repeated twice, the temperature each time being raised rather higher than on the preceding. The tap-hole is then pierced, and the lead is allowed to run out into the bason. The slag which remains behind upon the sole of the furnace is poorer in quality than that which flows with the lead into the bason, and is raked out by the assistant and put on one side for subsequent treatment by a separate process.

The result will probably be about 15 to 16 cwt. of metal, as it is usual at most works to mix the rich and poor ores together, so as to make a fair average quality of material. This plan has not only the advantage of rendering the working of the furnace regular, but the poor ores serve as a flux to the richer, and so render the use of an artificial one unnecessary. From 1 to 2 cwt. of lime is used to make the slags drier or less fusible, and the coal consumed for each charge will be about 10 cwt.

During the calcination the free admission of air causes the partial oxidation of the sulphide, so that the contents of the furnace at the close of that stage of the process will more or less closely agree with one or other of the formulæ given above, and contain all the elements for the double decomposition represented in those equations.

In Cornwall and some other parts, the calciner and the flowing furnace are separate. They are both made on the reverberatory principle. The sole of the former is flat, and there is no special feature connected with it to call for particular remark. That of the flowing furnace is hollowed towards the part opposite the channel through which the lead flows into the bason. The rich and poor ores are mixed together prior to calcination, so as to yield a mixture containing from 65 to 70 per cent. of metal. The roasting then proceeds gradually for about eighteen hours; the charge is raked over every hour, and a little lime is added from time to time to prevent the ore from clotting. The calcined ore is spread evenly over the hearth of the flowing furnace, and then the doors are closed and the heat got up for two or three hours, by which time the furnace will be ready to be tapped. This having been done, some lime is then thrown over the slag, and a little scrap iron introduced; the furnace-doors are again closed, and the temperature raised still higher. At the second running the lead will be succeeded by a regulus, which is usually tolerably rich in copper, and is sold to the smelters of that metal; the slag is then allowed to run into a pit at the side, and is so free from metal as not to be worth further manipulation.

The "ore hearth" is of quite another construction, and the principal fuel consumed in it is peat. Hence its suitability for the northern parts of the kingdom, where peat is the cheapest fuel. The construction of this (which is sometimes also called the Scotch furnace) may be understood from the accompanying diagram (Fig. 1), which represents a section from back to front merely of the working part. Above the upper line is carried a hood for collecting the heated fumes, and the flues by which they are carried off to the condensing chambers. The hearth-bottom itself is represented by A, the work-stone by B, in the centre of which is a groove for carrying any lead which flows over into the bason C. This last is kept warm by a small fire at D; E is called the pipe-stone, as it contains the funnel-shaped aperture which holds the twyer; and F the forestone, which extends across the front of the furnace, and which can be raised somewhat if a full charge should be worked, in which case the contents will reach as high as the dotted line.

In most cases it is found desirable to calcine the ores before reducing them by this process, though some qualities may work very well without this preliminary operation. A smelting shift, as it is termed, lasts from twelve to fifteen hours, and is worked by two men. When the ore-hearth is ready for work, the hearth-bottom A is already full of melted lead and brouse, the latter being the local name applied to a mixture of half-reduced ore and slag. A little coal is first sprinkled over the surface, and then the peat is built up in the form indicated by the dotted line; some peats already ignited are placed in front of the nozzle of the twyer, and the blast is immediately turned on. When the whole of the fuel is properly ignited, some brouse is thrown in on the top behind the fore-stone F. As soon as the lead begins to flow, the workman thrusts his poker into the hearth-bottom and stirs it up, which causes some of the contents to fall upon the workstone; any grey slag that may be mixed with it is separated and put on one side for future treatment, and the brouse (which has become further oxidised during its short exposure to the air while on the work-stone) is shovelled up and returned to the hearth along with some fresh ore. At each stirring of the contents, which is now repeated every five minutes, the assistant places a fresh peat in front of the twyer, and re-arranges the rest, so that the blast may be evenly distributed throughout. When the receiving-pot is sufficiently full of lead, the one man keeps the surface skimmed while the other ladles the lead out into the pig-moulds. The metal produced by this process is usually very pure, as the temperature employed is too low to reduce any of the other metals there may be in the ore, except the silver, which always comes over with the lead.

Whether the reverberatory or the blast furnace be used, it will be seen from the foregoing descriptions that there are certain slags, the grey or furnace slags, which are put on one side to be treated separately. These consist principally of the oxide of lead with occasionally a little both of the sulphate and sulphide, and a large proportion of earthy ingredients, such as silica, baryta, lime, etc. When a sufficient quantity of these slags have been accumulated they are reduced in another kind of blast-furnace called the slag-hearth.

Figs. 2 and 3 will give the elevation in section, and a horizontal plan of this furnace on the level of the twyer. The construction of it will be very readily understood from the drawings. The slags which have to be reduced in this hearth seldom contain so much as 35 per cent. of lead, and are altogether more refractory in their composition, so that a much greater heat is required; and a mixture of coke and peat is selected as the fuel in the north of England.

About one and a-half to two hours are employed in getting the furnace up to a sufficient temperature, when the grey slag mixed with a little brouse is thrown in. After a sufficient time has elapsed to admit of the lead having begun to separate, the furnace-man makes a hole with a pointed iron rod in the clay stopping immediately below the fore-stone A, and the slag then runs out over the lead through B into the slag-pit C. The lead trough, it will be seen, is divided into two compartments, which communicate with one another by a little hole at the bottom of the iron plate which separates them. The larger compartment is filled up with spongy cinders, which act as a filter, the lead percolating through them and passing on to the smaller compartment, while the slag flows on to C. At the close of the operation, the clay stopping is all removed, and the imperfectly reduced slag remaining on the floor of the hearth (which is called slag-hearth brouse) is raked out and put on one side for use in the next shift. Slag lead is rarely so pure in quality as the metal yielded by the regular processes, as it is necessary to employ a temperature which will reduce the iron and other metals that may be in the slags.

In the foregoing descriptions we have purposely omitted all reference to the arrangements for the collection of the fumes arising from the expulsion of the sulphur, and more particularly from the partial volatilisation of the lead itself. It will be remembered from the description given of copper smelting (Article XX.), that the sulphurous acid evolved is destructive to all vegetation; but beyond this the lead salts are all highly poisonous, and if they were allowed to escape into the air from a short chimney, the water and all the herbage and plants around would become so affected by them as to be unfit either for human or animal food. A large quantity of lead would in such case also be irrecoverably lost. The arrangements for the collection of this lead must be reserved for another article.

BUILDERS' QUANTITIES AND MEASUREMENTS.—XVI.

BY E. WYNDHAM TARN, M.A.

We now resume the dimensions of work done by the plumber, zinc-worker, gas-fitter, glazier, painter and decorator, and paper-hanger commenced in our last paper.

GLAZIER.

4)	4 8 3 4	62 3	Glazing with 2nds crown, in squares 14″ × 10″.
2)	6 0 3 0	36 0	Ditto best, ditto, ditto, 18″ × 12″.
	6 6 3 0	19 6	Ditto best British sheet, ditto 30″ × 18″.
	6 6 3 0	19 6	Polishing ditto.
	7 0 10 6	73 6	Glazing with best Brit. plate, in sqres. 7 ft. × 3 ft. 6, ½ in. thick.
	4 0 2 6	10 0	Ditto, ditto, in sqrs. 48″ × 15″.
	7 0 3 6	24 6	Extra bendg. plate glass.
	4 6 3 0	13 6	Glazg. with rough plate, in sqrs. 27″ × 18″.
6)	8 0 2 0	96 0	Glazing in lead quarries, with tinted cathedral, copper ties, and cementg. into stonewrk.
	3 0 2 0	6 0	Hacking out old glass.

No. 8 doz. sqrs. cleaned.
„ 4 glass tiles, 20″ × 10″.

PAINTER AND DECORATOR.

12)	6 8 3 6	280 0	Knottg. primg., and 4 oils.
4)	6 8 3 6	93 4	Grd. wainscot and 2ce. varnd.
	7 0 5 0	35 0	4 oils, skylight.

2)	48 0 9 0	864 0	4 oils and flat to plaster, find. ash green.
2)	15 0 2 6	75 0	3 oils to balusters.
5)	48 0	240 0	4 oils skirting.
2)	48 0	96 0	Skirtg. grd. w., and 2ce. varnd.
	34 0	34 0	3 oils cuttg. to stairs for carpets.
	40 0	40 0	4 oils staff bead.
	16 0	16 0	2 oils edge of shelf.
2)	15 0	30 0	3 oils strings.

No. 4 sash frames 4 oils b. s., 6 ft. by 4 ft.
„ 2 ditto, ditto, 8 ft. by 5 ft. 6 in.
„ 8 dozen squares, ditto, small.
„ 2 ditto, ditto, large.
„ 2 small casements, ditto.
„ 4 stone chimney-pieces, 5 oils.
„ 3 shutter bars, 3 oils.

2)	6 6 3 0	39 0	Staining, sizg., and 2ce. varng.
	8 6	8 6	4 in. letters in gold and shaded.
	48 0	48 0	Gilding 1 in. mouldg.
	24 0 15 0	360 0	Distemper 2 tints.

PAPER-HANGER.

	48 0 10 0	480 0	Hanging 1d. paper, includg. sizing to walls.
	56 0 11 0	616 0	Ditto, 2d. ditto, ditto, and lining paper.
	65 0 12 0	780 0	Ditto, 6d. ditto, ditto, ditto.
	52 0 10 6	546 0	Pumicing, sizing, and stripping old paper, and hanging with 4d. paper.
	40 0 10 6	420 0	Canvas lining for paper.
	75 0 12 0	900 0	Preparg. walls and hanging marbled paper 3d. per yd. on a lining paper, hung in blocks, sized and varnd.
2)	48 0	96 0	Borders.
2)	65 0	130 0	Gold mouldg., 1 in. wide, fixed with needle-pts.

Having completed the series of imaginary dimensions for the plumber's work, etc. etc., we now proceed to form an abstract of them as before. This abstract might have been disposed across the page, so as to exhibit the whole of the work required in the different branches specified, in one table. For convenience' sake, however, it has been found advisable to present the work of the plumber, zinc-fitter, gas-fitter, and glazier in one abstract, and that of the painter and paperhanger in another.

ABSTRACT FOR PLUMBER, ZINC-FITTER, ETC.

Plumber.		Zinc-ftr.	Gas-ftr.	Glazier.
Milld. lead, roof. ft. 720 7 112) 5040 45 cwt.	Number. Solder jt., ¾ in. pipe. 2	Supl. 25 oz. in flat. ft. 126 0	Run. 1 in. w. i. welded tubing. ft. 55 0	Supl. Glazg. 2nd cr. in sqrs. 14″ × 10″. ft. 62 3
Ditto gutters. ft. 37 6 6 112) 225 2 cwt. 1 lb.	Ditto 1 in. 2	Run. 4 in. eaves gutter. ft. 24 0	½ in. tin ditto. ft. 30 0	Ditto best ditto, 18″ × 12″. ft. 36 0
Ditto hips. ft. 105 6 112) 630 5 cwt. 70 lb.	Ditto 1¼ in. 2	2½ in. R. W. P. ft. 30 0	Number. Short pieces 1 in. tubing. 5	Ditto best Brit. sheet, 26 oz., 39″ × 18″. ft. 19 6
Ditto step flashg. ft. 42 6 5 112) 212½ 1 cwt. 100½ lb.	Ditto 1½ in. 2	Number. Oct. head to R.W.P. 2	Bends ditto 3	Polishg. ditto. ft. 19 6
Ditto cistern. ft. ft. 37 6 12 6 6 7 225 87½ 225 112) 312½ 2 cwt. 88½ lb.	1½ in. br. washer and waste. 2	Shoes ditto. 2	Tees ditto. 2	Glazg. best Brit. plate, ½ in. thick, 7 ft. by 3 ft. 6 in. ft. 73 6
Run. Sold. angle, cistern. ft. 17 6	1¼ in. trumpet waste 2 ft. 3 in. long. 1	Nozzles ditto. 2	Cross ditto. 1	Ditto, ditto, 48″ × 15″. ft. 10 0
Close nailg. c. nls. ft. 15 0	Service box. 1	Stopd. ends gutter. 4	Connectg. piece. 1	Rough plate. ft. 13 6
¾ in. strong pipe and joints. ft. 12 0	¾ in. ball ck. and c. ball. 1		1 in. stop-cock. 1	Bending plate. ft. 24 6
1 in. ditto. ft. 45 0	Ditto bib ditto. 1		½ in. union jts. 8	Glazg. in ld. quarries, tintd. cath., copper ties, cementd. to stone. ft. 96 0
1½ in. ditto. ft. 35 0	1 in. stop ditto. 1		12 in. plain bracket. 4	Hacking out old glass. ft. 6 0
1½ in. ditto. ft. 16 0	D-trap. 1		24 in. dble. ditto. 2	Number. Squares cleand. 8 doz.
5 in. soil pipe. ft. 32 0	Syphon in 1½ in. pipe. 1		Pendant, hydraulic joint. 1	Glass tiles, 20″ × 10″. 4
	W.C. appr. 1		5 light chandelier. 1	
	Br. gratg. sold. 1			
	2½ in. force-pump. 1			

ABSTRACT FOR PAINTER AND PAPERHANGER, ETC.

PAINTER AND DECORATOR.				PAPERHANGER.
2 Oils.	*3 Oils.*	*4 Oils.*	*5 Oils.*	
RUN. Shelf edge. ft. 16 0	SUPL. Balusters. ft. 9) 75 0 8⅓ yds. RUN. Cuttg. to treads of stairs. ft. 34 0 Strings. ft. 30 0 NUMBER. Shutter bar. 3	SUPL. Knottg. and primg. on deal. ft. 9) 280 0 31 yds. Ditto skylight. ft. 9) 35 0 4 yds. Flattd. to plaster, ash green. ft. 9) 864 0 96 yds. RUN. Skirtg. knottd. primed. ft. 240 0 Staff bead. ft. 40 0 NUMBER. Sash frames, b. s. 6 ft. × 4 ft. 4 Ditto. 8 ft. × 5 ft. 6 in. 2 Small squares. 8 doz. Large ditto. 2 doz. Small casements. 2	NUMBER. Stone chimney-piece. 4 GRAINING AND VARNG. SUPL. ft. 9) 93 4 10½ yds. RUN. Skirting. ft. 96 0 STAINING, &c. SUPL. Sized and varnd 2co. ft. 9) 39 0 4⅓ yds. SUPL. Distemper 2 tints. ft. 9) 360 0 40 yds. RUN. 4 in. letters, gold and shaded. 102 inches. 1 in. moldg. gilt. ft. 48 0	SUPL. Pparg. walls and hangg. 1d. paper. ft. 5) 480 0 12) 96 0 8 pieces. Ditto, ditto 2d. and lining paper. 5) 616 12) 124 11 pieces. Ditto, ditto 6d. and ditto. ft. 5) 780 0 12) 156 0 13 pieces. Canvas lining. ft. 9) 420 0 47 yds. Marble paper 3d. on lining paper, in blocks, lined, sized and varnd. 5) 900 12) 180 15 pieces. RUN. Border. ft. 3) 96 0 12) 32 0 3 doz. yds. 1 in. gold moldg. with needle-points. ft. 130 0

NOTABLE INVENTIONS AND INVENTORS.

XXX.—ISAMBARD KINGDOM BRUNEL.

BY JOHN TIMBS.

THIS great and original engineer was the only son of Sir Isambard Mark Brunel, and was born at Portsmouth in 1806. As Normandy was the birthplace of both his parents (his mother being a Miss Kingdom, of Rouen), his choice of a school, the college of Henri Quatre, is reasonably explained. He was, as it were, born an engineer, and those who recollect him as a boy will remember how rapidly, almost instinctively, he entered into and identified himself with the plans and pursuits of his father. The son was very early remarkable for his power of mental calculation, and for his rapidity and accuracy as a draughtsman. Nor was this power confined to mechanical drawing, for he thus early evinced a love of art and artistic feeling which characterised him through life. His father watched these early indications, and his education was directed to qualify him for the profession in which he afterwards became distinguished. At the age of fourteen he was placed under the care of Mr. Masson, before he entered the college at Caen, where he remained two years. He there completed a sound, practical education, and learned to observe and investigate facts, to generalise them, and from such inductions to deduce sound rules for practical conduct.

From Caen Brunel returned to England, and commenced his professional career as his father's assistant in the Thames Tunnel works. The energy and ability he displayed in mastering the physical difficulties in this great scientific struggle are duly chronicled in its records; and it has been shown that at this time the anxiety and fatigue he underwent, and an accident he met with, led to future weakness and illness. In one of the irruptions the rush of the water carried him up the shaft. In his descent in a diving-bell to examine the breach made by the irruption the bell was lowered about thirty feet, to the mouth of the opening; but the breach was too narrow to allow it to go lower, that the shield and other works, which lay eight or ten feet deeper, might be examined from the bell. Mr. Brunel, therefore, took hold of the rope, and dived below the bell for the purpose. After he had remained under water about two minutes, his companion in the bell became alarmed, and gave a signal which caused Brunel to rise, when he was surprised to find how much time had elapsed—a circumstance accounted for by the condensation of the air in the bell, from which his lungs were supplied by the pressure of a column of water nearly thirty feet high, which would condense the air into nearly one-half of its usual bulk. Upon a similarly trying occasion Brunel, being an expert swimmer, saved the lives of several workmen at the risk of his own. He was welcomed with a hearty and respectful cheer by the workmen, who crowded round him and wept like children as they affectionately grasped his hand; and the wives of the men he had saved fell on their knees before him, imploring blessings upon him; others cut little pieces from his coat, which they long treasured as relics.

Brunel at an early age possessed the advantage of being able to express or draw clearly and accurately whatever he had matured in his own trained mind. He could also work out with his own hands, if he pleased, the models of his own designs, whether in wood or iron. As a mere workman he would have excelled. Even at this period steam navigation occupied his mind, for he made the model of a boat, and worked it with locomotive contrivances of his own. Everything he did with all his might and strength; and the same energy, thoughtfulness, and accuracy, the same thorough conception and mastery of whatever he undertook, distinguished him in all minor things. ("Stories of Inventors and Discoverers," 1860.)

After the suspension of the Thames Tunnel works, Mr. Brunel became employed on his own account at various works. At Bristol and Sunderland he constructed docks, and he designed a suspension bridge across the Avon at Clifton. When a railway was contemplated between London and Bristol, and a company formed, Brunel was appointed their engineer; and curious it is to read the report of a lecture delivered at Bristol, in the year 1833, by John Britton, the antiquary, upon this means for reviving "the commerce of the west." Brunel's earliest works were on the Bristol and Gloucestershire, the Merthyr and Cardiff, and several colliery tramways, when his mind was first turned to the construction of railways. He was appointed engineer of the Great Western Railway Company, being then only about twenty-eight years of age, but skilful and ingenious, and anxious to strike out an entirely new course of railway engineering. From the great proportion of passenger traffic expected it was proposed to travel at a higher speed upon this line than had been attained upon any other railway. With this view the permanent way was to be peculiarly laid, principally in fixing the gauge at seven feet, a much greater width than had hitherto been adopted, and by which greater steadiness could be ensured than otherwise was consistent with high speed. "The directors seem early to have had misgivings as to the expediency of the change introduced by their engineer; and in 1838, while the line was still under construction, they invited several engineers of eminence to advise with them on the subject. Robert Stephenson and James Walker declined to do so; but Nicholas Wood and John Hawkshaw consented. Both sent in reports which concurred in recommending the adoption of the *narrow* or established gauge, in place of the *broad* or exceptional one. Mr. Hawkshaw clearly pointed out that the existing gauge had originated in experience, and that the men whose practical knowledge of railways had been greatest saw the least occasion for its alteration; that three-fourths of England was being traversed by the narrow gauge, and it would be a great evil if the Great Western district were to be isolated from all the great lines in its neighbourhood; that nothing was to be gained by increasing the width of the gauge, while much might be lost by the unnecessary expenditure of capital in the first place, and by driving traffic in other directions in the next; and under these circumstances he strongly urged that, as only twenty-two miles of the railway had been laid down at the date of his report, that portion should forthwith be converted into narrow gauge, and the remainder executed of the same width. Mr. Hawkshaw's recommendations were of no avail. Mr. Brunel, Mr. Babbage, and Mr. Russell Gurney opposed their adoption by the company: genius, science, and eloquence carried the day. Mr. Brunel assured the shareholders that the broad gauge was the best gauge, and that the Great Western 'could have no connection with any other of the main lines of railway.' On a division the shareholders endorsed the recommendations of their engineer, and the controversy was for a time put an end to by the completion of the Great Western as a broad-gauge railway, which was so novel that it was called the Grand Experimental Railway; while it rendered Brunel famous as a railway engineer.

"Years passed, and railways of a different gauge met Mr. Brunel's line at many points. Mr. Brunel himself was the engineer of various lines of narrow gauge, thereby admitting its practical sufficiency for railway traffic. The *break of gauge* eventually came to be viewed in the light of a public calamity. The intervention of Parliament was even called for, and a Royal Commission was appointed to take evidence and report on the subject, which they did in 1846. But it was too late to remedy the evil. While an actual saving of capital would have been effected by the adoption of Mr. Hawkshaw's recommendation eight years before, it was now found that the alteration of the Great Western lines from the broad to the narrow gauge would cost upwards of a million sterling. How was this amount to be raised? By the shareholders, or by the public? The question was, indeed, felt to be surrounded with difficulty; and all that the commission did was to recommend the future restriction of the broad gauge lines to their own district. Since that time something has been done to remedy the original evil: the mixed gauge—that is, the narrow gauge with the broad—has been adopted, and gradually extended."

Among the Great Western constructions are the viaduct at Hanwell; the Maidenhead Bridge, which has the flattest arch ever attempted in brickwork; and the Box Tunnel, which at the date of its construction was the longest in the world. The excavation through the solid rock of the latter was satisfactorily accomplished under the direction of Mr. Brunel. This tunnel, which is ventilated by six shafts, varying from 70 to 300 feet in depth, is 3,173 yards in length. It pierces through Box Hill, between Chippenham and Bath, part of which is 400 feet above the level of the railway. The number of bricks used in its construction was 50,000,000; a ton of gunpowder and a ton of candles were consumed every week for two years and a half; and 1,000 men and 250 horses were kept constantly employed.

The tubular bridge over the Tamar, together with the similar bridge over the Wye, the "bowstring girder bridge" at Chepstow, are imposing monuments of Mr. Brunel's boldness and skill. The principle upon which these bridges were planned has been much criticised, but the works executed undoubtedly possess great strength and durability. The foundations of these bridges, under the customary modes adopted with such works, would have been extremely difficult of execution; but Mr. Brunel's ready appreciation of the merits of new discoveries enabled him to take full advantage of the pneumatic process, by a modification of which he established the foundation of the principal pier of the Saltash Bridge, at a depth of water and soft mud at which no works of the kind had been previously founded. It consists of nineteen spans, seventeen wider than the widest arches of old Westminster Bridge; while the other two, resting on a cast-iron pier of four columns, cross the whole stream of the Tamar, at a leap of upwards of 900 feet, or a greater distance than the breadth of the Thames at Westminster. The total length of the structure from end to end is 2,240 feet; its height from foundation to summit is 260 feet, or more than 50 feet higher than the London Monument. The main pier in the centre of the river, on which the great spans rest, has its foundation on solid rock, under some 70 feet of sea-water, with 20 feet of mud and concrete gravel. This was built on the coffer-dam principle. An immense wrought-iron cylinder of boiler plate, 100 feet high and 37 feet in diameter, and weighing upwards of 300 tons, was made and sunk exactly on the spot whence the masonry was to rise; then the water was pumped out and the air forced in; the men descended, and, working as in a gigantic diving-bell at the bottom of the river, cleared out the mud and gravel, until the rock was reached and hewn into form to support the cylinder evenly all round. Powerful steam air-pumps were necessary to keep the labourers supplied below; and they worked at an atmospheric pressure of upwards of 35 lbs. to the inch. On this massive pile, built in the cylinder, the iron columns for the centre pier are raised. Until these ponderous masses were cast, metal works of such dimensions were seldom dreamt of. There are four octagonal columns 10 feet in diameter, 100 feet high, and 150 tons weight. These columns stand 10 feet apart from each other, in the centre of the granite, and are bound together with a massive lattice-work of wrought iron. The great spans, each of which has one end resting on two of these columns, are made on the principle of a double bow; the lower one is of chains, carrying the roadway; the upper is a tube of wrought iron, to which the lower is attached by powerful supports. Thus, a great weight on the lower bow only tends to give additional support by strengthening the upper, and *vice versâ*; each, in fact, counteracts the effect of the other. Each arched tube is elliptical in form, and made throughout of inch boiler-plate, with inside wrought-iron diaphragms, with tie-rods and angle-irons. The pressure on the centre pier foundation is more than eight tons to the foot; the whole work involved six years' toil, anxiety, and peril. The Chepstow Bridge has a span of 306 feet, besides three side spans of 100 feet each.

TECHNICAL DRAWING.—LXXIII.

DRAWING FOR BRICKLAYERS.

IN addition to the positions already mentioned, brick arches are also used under the following circumstances:—

When the whole or part of a front is to be covered with cement, straight arches are sometimes built rough in the following manner:—At the key or crown of the arch fragments of bricks are laid, cut to the form of the letter V. All the others are whole bricks, parallel sided, but diverging inwards in contrary directions, and cut at top and bottom only to the splay. This can scarcely be said to carry out the arch principle, and is not by any means to be recommended. INVERTED arches are generally used in bad or doubtful foundations, and often even in good foundations, immediately under the apertures of the doors and windows. These may either be segmental, semi-circular, or parabolic.

In storehouses, stables, etc., where much light is not required, semi-circular openings are sometimes made arched at top, with a sill at the bottom.

In the basement storey of buildings small circular apertures, technically termed "bull's-eyes," are sometimes made, which are arched all round, so as to possess the properties both of common and inverted arches. These, however, seldom exceed three feet in diameter.

Rough arches are often used to support the flues of chimneys, whenever it is required to change the direction of those flues, in order that those belonging to distant fireplaces may be brought up in the same shaft at the top of the house.

Arches for coal-cellars, etc., are often built opposite to the basement storey of houses, beyond the area, so as to extend below the pavement of the street. These arches are commonly semi-circular, one brick thick, not exceeding nine feet in span, and having pier walls of one and a half or two bricks in thickness—that is, when there is a continued range of them; they being supported at the extreme ends by abutments of greater thickness when necessary.

In plan the pier walls of such arches usually serve to support horizontal arches, forming the extreme ends of the same vaults, which are thus enabled to resist the pressure of earth of the street or external ground. Arches of this description may be seen in the side walls of the Metropolitan Railway.

DRAINS AND SEWERS.

The purpose of these lessons precludes our entering further into this subject than to describe some of the forms of drains used for carrying off sewerage, and our illustrations must necessarily be limited to such as are constructed of bricks to the exclusion of drain-pipes formed of earthenware.

From every water-pipe carrying off rain-water from the roof of a building, as well as from every sink and water-closet, a small drain leads into a greater one, the former of which is called a branch drain, whilst the latter is called the principal drain of the building. The latter likewise receives the water from all the areas, and also often from the grounds in the immediate vicinity of the building, which for this purpose is levelled at a gentle slope, and has surface-drains or gutters leading to iron gratings over the main drains by which the water descends after rain.

Branch drains when built of brickwork are of three kinds:—

1. Flat at the bottom, with perpendicular sides and arched at the top, like the section of a small gallery. This kind of drain is built of various sizes, from 9 to 24 inches wide. In the first, three courses of bricks would be employed, the walls and arch being 4½ inches thick; in the latter the walls would, as a rule, consist of eight courses, the custom being to make the height to the springing correspond with the width. The arch, as explained in a former lesson, would be formed of two concentric rings, 4½ inches each.

2. The barrel or circular drain. The smallest size used is 9 inches in diameter, which is built with a 4-inch arch. This size is considered sufficient for carrying off clean water.

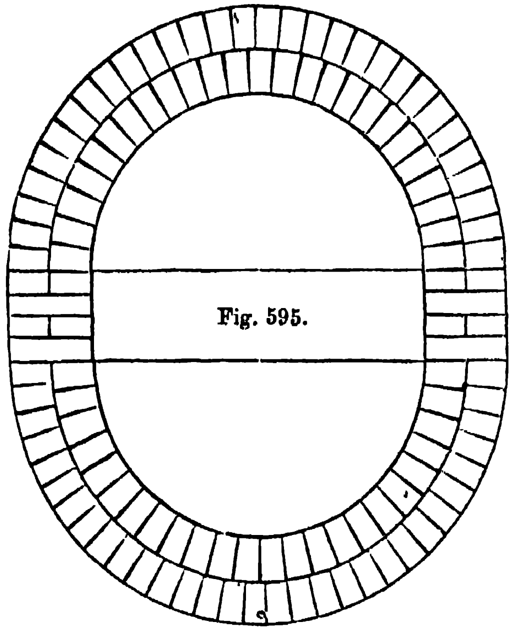
Fig. 595.

Barrel, or, as they are sometimes called, gun-barrel drains, are the best in exposed situations, because of their strength; but as, unless by some special construction, there is no mode of cleaning them without breaking them up if they are too long to be raked, they should not be employed except with a considerable fall and a frequent or constant stream of water through them, as from a pump, trough, rain-water tank, etc. They are constructed on a barrelled centre, which the bricklayer drags on as he advances with his work, finishing as he goes.

In this, as in all small arched forms when built of the rough bricks, the joints must necessarily open very wide at the extrados or outer ring, for the reasons previously stated. Hence in the drains at the Ordnance Barracks at Chatham the bricks were ordered to be cut and gauged. When this is not done, pieces of broken bricks, tiles, etc., should be put between the bricks at the outer ends of the joints instead of using all cement or mortar.

In barrel drains of larger diameter, the circular arch is formed of several 4½-inch concentric rings of brickwork. The slope of a drain for clean water may be from 1½ to 2 inches in 10 feet: the slope for a drain carrying down other sewerage should be from 2 to 3 inches in 10 feet, where such a slope can be commanded. The barrel form is that generally adopted for small drains, for which there seems to be good reasons, as the circle is the most compact and strongest form, and gives greater velocity, or, as it is termed, a sharper run to the water than a flat-bottomed drain of the same width.

All sewers, in fact, which are intended to convey anything more than water should either be cylindrical, or be built with concave bottoms, although the sides be parallel and the covering horizontal. The concave channel keeps the stream more together, and better enables it to carry its impurities along with it; whereas a flat-bottomed drain offers a large surface for the particles of soil to attach themselves to; and further, the stream of water being more scattered is less efficient in force.

Drains, in places where it may be necessary to open them at any time, should be somewhat of the form of the letter U, semicircular at bottom, and raised for a few courses above the inverted arch; the whole being covered with a flat stone. The obvious advantage of this arrangement is that the drains may be opened and examined without materially deranging the work; whereas the small drains constructed wholly of brickwork cannot be thus examined without taking the upper part of the arch to pieces.

In all small drains, except those for clean water only, it is necessary to have cesspools considerably larger and some feet deeper than the drain or drains to which they belong.

These cesspools being covered by a stone or iron plate, or sometimes by a grating, receive the sand or earth washed down, and thus prevent the drains from being choked up; and when the cesspools themselves are nearly full, which should be ascertained by the persons in charge of the building, they must be emptied out by removing the stone or iron covering, which is replaced after the clearing is effected. Besides these cesspools, it is usual to form much smaller ones of a different description, usually termed "stink-traps," to prevent offensive smells from passing along the whole extent of a drain. They are made by forming part of the bottom of a drain at a lower level, so that water must necessarily stand in it at all times, although the body of the drain may be occasionally dry.

Into the little pool of water thus formed a vertical stone or plate of iron is fixed from above, the under part of which enters lower than the surface of the water. This arrangement, without impeding the regular course of water in the drain, which finds its level after entering beneath this stone or plate, prevents in a very great measure the passage of foul air.

These traps are now made of iron or earthenware, and should be well studied by the bricklayer, so that he may understand their action.

Care should be taken in arranging the small drains of a building that nothing but the clean water drains shall have any possible communication with the tanks or cisterns for receiving rain-water from the roofs when such are used.

When the principal drain of a building is within a few feet of the surface, it may be formed of bricks or earthenware pipes large enough to carry off with ease the greatest quantity of water that can come from the branch and surface drains.

This arrangement is not, however, always practicable. In every building having a basement storey it becomes a necessity that the bottom of the drain should be below the level of the area. In this case, but more especially where the drains pass under pavements, roads, walls, etc., which cannot conveniently be disturbed, it is proper to make them large enough for a man to go through and examine any part of it. Drains of this description are termed sewers or culverts, to distinguish them from the smaller kinds before described. The smallest sized opening in which a man can well move by stooping is one of 2½ feet in width by 3½ feet in height.

Such sewers may be elliptical in section, oval, or egg-shaped—*i.e.*, wider at top than bottom—or they may have vertical sides with semicircles or arcs at top and bottom.

Fig. 595 is a section of a drain of the kind last mentioned. In this example it will be seen that the walls of the drain are one brick in thickness, the upper and lower arches being formed of two 4½-inch rings. These are formed of bricks laid on edge, and are not rubbed to the splay, which is not deemed necessary in arches of this character and span.

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